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Andromeda

To the mind filled with classical lore the word of the title suggests "the chained lady." This characterization brings in its wake the legend of a beautiful woman chained to the rocks on the seashore and left to the mercy of the sea monsters in order to appease the wrath of the sea god. So realistic had this legend become to the ancients that Josephus wrote in the first century of the Christian era that the links of the chain and the bones of the sea monster, which had devoured its victim, might then still be seen.

But to the astronomer the word suggests a well-known northern constellation. He uses the name from day to day without any thought of the bygone mythology involved. Moreover, the astronomer, for the most part, directs his attention to a single feature in this constellation called the Great Nebula in Andromeda. This object is so situated in the sky that it is well above the horizon through most of the night in mid-winter in the northern hemisphere. When the sky is clear and the moon is absent this so-called nebula is faintly visible without the aid of a telescope to a person of fairly good eyesight.

Granting our present knowledge of this object, if it were named today it would not be called a nebula. Strictly speaking, a nebula is a cloud-like mass of self-luminous gas. As seen with the naked eye, this object conforms to this description. But the telescope reveals quite a different situation. It is so far away that it is not a part of our galaxy, hence it is said to be extra-galactic. It is now known to be very similar in constitution and in size to the galaxy, or Milky Way System, which was once thought to comprise the entire universe. In viewing this distant stellar system we may, indeed, have a picture of our stellar system as it would appear if it were seen from a distance. The view, however, cannot be considered as contemporaneous. The light reaching us today from the Andromeda nebula started on its journey some 900,000 years ago. We, therefore, see it as it was in what to us is the unimaginable past. The time-interval involved here is approximately three times that during which human life has existed on the earth. The distance interval in miles is indicated as 54×10^{17}, 54 followed by 17 zeros.

Nevertheless, this nebula is referred to as one of the nearest of the extra-galactic nebulae. It is a first step in exploring the universe. Having taken the first step, a second one similar to it confronts us. It is necessary to take approximately 150 such steps before arriving at the most remote nebula disclosed by the 100-inch telescope. The expectation is that the 200-inch telescope will double this distance.

Man's physical and direct explorations are small and definitely prescribed; his mental and indirect explorations are stupendous and apparently unbounded. C.H.G.

The Problem of the Beta Cephei Stars*

By OTTO STRUVE

In the November issue of *Sky and Telescope* I presented a popular review of this problem; and the forthcoming issue of the *Astrophysical Journal* will bring the more technical results derived from the work of W. F. Meyer at the Lick Observatory on the radial velocity of β Canis Majoris.

More recently I have been engaged in a spectrographic study of the star 12 Lacertae, which resembles β Canis Majoris. At the same time I have secured a long series of spectrograms at the Lick Observatory of β Cephei, and a shorter one of σ Scorpii. Miss Jane Ramsey is measuring these plates.

Last summer Mr. Merle Walker of this department discovered a new bright variable of the β Cephei group: the spectroscopic binary 16 Lacertae has a light curve of variable amplitude, whose period is 4 hours. The radial velocity varies in the same period.

It is clear that many B-type stars belong to this group of variable radial velocity. Presumably all are variable in light. Many remain to be discovered, even among stars of naked-eye brightness.

Earlier investigations of their light curves by J. Stebbins, P. Guthnick, E. A. Fath, and O. J. Eggen have given much valuable information. But we require more material—with photoelectric precision—and with a heavy concentration of the observations during a single season for any given star. Mr. Walker is planning to conduct such observations at Lick and perhaps at Berkeley. But we should like to invite other photoelectric observers to cooperate with us in this task.

Our program will be divided into two parts: I. The photoelectric discovery of new variables of the β Cephei class, and II. the intensive study of a few bright variables simultaneously with the photometer and with the spectrograph. It is for this second part of the work that we would like to enlist one or more cooperating institutions. During the present winter Dr. D. McNamara and I shall observe β Canis Majoris with the spectrographs of the Lick and Mount Wilson Observatories. It would enhance the value of our work if some photoelectric observer should obtain accurate light curves on as many nights in January and February as is possible. There are two periods, $6^h\,0^m$ and $6^h\,2^m$, respectively. The spectrographic velocity amplitudes are not quite the

*Presented at the Cleveland meeting of Section D of the American Association for the Advancement of Science.

same: 12 km/sec and 8 km/sec, respectively. The beat period is 49 days. Is there a similar, double period in the light curve?

Next summer we plan to observe intensively σ Scorpii, and perhaps also 12 Lacertae and β Cephei. Photometrically, 12 Lacertae is especially easy. Fath, in 1947, announced three periods of which the longest agrees with R. K. Young's spectrographic period.

I need not take much time to explain the significance of these observations. The spectrographic results show, in the case of 12 Lacertae, double absorption lines—*approximately* at the times of maximum and minimum brightness, which times are also those when the velocity curve passes through gamma. Yet, we cannot explain the two lines as coming from two bright components of a binary system: there is not enough room to fit two equally luminous B-type stars within the dimensions of the spectroscopic orbit.

Hence, the two lines must come from two diametrically opposite "spots" (or hemispheres) of a single star. And the succession of, first, double lines with the sharp component to the violet, then of a single sharp line, which is followed by a double line with the sharp component on the red side, and finally by a single broad line—must mean that the two "spots" travel along the equator of the B star.

What causes them to travel with a period of 4½ hours? Not rotation! The lines are not broad enough for that. The only explanation I can think of at present is the existence of a very small, very dense companion star—perhaps a large planet or a white dwarf—which revolves near the surface of the B-type primary and drags along with it a turbulent "wave" or "bulge" that may actually envelop the small companion in the manner in which gaseous streams are known to envelop many close binary systems. The interaction between the orbital period and the period of free vibration of the star's atmosphere may, in fact, account for the amazing similarity in the two periods of β Canis Majoris.

We cannot go much further without additional observations. But few other astrophysical problems appear to me at this time to be so "ripe" for a significant advance in knowledge. I am making this appeal now because there are so many new photoelectric observers in this country who are equipped with instruments of high precision. The work is certain to give prompt results: a single night's observations may be valuable; and two months' observations covering 10 or 20 complete cycles should be helpful in deciding whether the individual light curves vary in range and period as do the velocity curves.

The work of the cooperating observers should be conducted independently, and should ultimately be published apart from each other. But we could pool our information in advance of publication, and, even more important, concentrate upon the same stars during the same nights.

Berkeley Astronomical Department, University of California,
December 2, 1950.

The Discovery and Exploitation of Spectroscopic Parallaxes*

By DORRIT HOFFLEIT

(Continued from **58**, *501)*

The Line-Character Criterion: Justification and Contention

Somewhat later work, especially at Yerkes Observatory, (Struve, *Ap. J.*, **69**, 173, 1929; *Pop. Ast.*, **43**, 496, 1935; Hynek, *Ap. J.*, **83**, 478, 1936) sought to find the physical significance of the difference between the *n* and *s* characteristics. In 1929, Struve, investigating the Stark effect in stellar atmospheres, found that the line widths in the various B subtypes were well correlated, inversely, with the central intensities of the lines. But he showed that the dispersion of line widths, especially of the hydrogen lines, could not be attributed to a single cause. The width of a line must be the resultant of at least three contributing factors: rotational broadening, Stark effect, and abundance. Thus the observed dispersion in the line-widths would be given by

$$\sigma_{obs} = \sqrt{\sigma^2_{rot} + \sigma^2_{Stark} + \sigma^2_{abundance}}$$

The Stark effect widening he showed to be proportional to the three-halves power of the partial electron pressure. Since the partial electron pressure might be assumed to be proportional to the total gas pressure, it followed that an absolute magnitude effect should be observed in the line widths, such that the difference ΔM between the absolute magnitudes of two stars whose line widths (for a given line, *e.g.*, Hγ) are W_1 and W_2 is

$$\Delta M = k \log (W_1/W_2)$$

where k is a factor of proportionality. The relation indicated that a star whose spectrum shows narrow lines should be more luminous than one with a broad-line spectrum. And this he felt was amply confirmed by the Mount Wilson spectroscopic absolute magnitudes (Fairfield and Lindblad criticisms notwithstanding), as well as by his own unpublished investigations and those of others, notably at the Norman Lockyer Observatory (see Table V, second part).

In "Some new Trends in Stellar Spectroscopy," in *Popular Astron-*

*Please note corrections to the part of this paper in preceding issue (December, 1950) as follows:

1. Page 493, line 10, *for* comparison *read* comparisons.
2. Page 493, line 30, *for* Hale *read* Gale.
3. Page 496, line 26, *for* H *read* Hγ.
4. Page 496, line 29, *for* 4335 *read* 4435.
5. Page 496, line 34, *insert as third item* $\frac{4408\ \text{Ti} +}{4415\ \text{Fe, Sc} +}$.
6. Page 499, line 6, *for* Stromberg *read* Strömberg.
7. Page 500, line 5 from bottom, *for* and F0 *read* to F0.

omy in 1935, Struve discussed the various known and suspected factors contributing to the broadening of lines in stellar spectra. These were summarized in a block diagram showing the following components:

A. Physical Causes (Abundance)
1. Natural width (Radiation damping)
2. Compton Effect
3. Collision Damping
4. Changes in Absorption Coefficient
   a. Stark Effect
   b. Zeeman Effect
   c. Thermal Effect
   d. Turbulence
   e. Resonance
   f. Auto-ionization

B. Mechanical Causes (Doppler Effect)
1. Convection
2. Expansion
3. Rotation

While some of these factors vary with pressure or absolute magnitude, others may be fully as effective in the line broadening without being either directly or indirectly significantly dependent on stellar luminosity. In seeking to justify the utilization of line-widths as absolute-magnitude criteria, it is therefore important that those broadening factors that are not influenced by absolute magnitude be relatively minor contributors. The two perhaps most powerful factors among the early-type stars are found to be rotational Doppler effect and the Stark effect. As we have seen, it had already been observed that the more luminous stars rotate more slowly than the lower luminosity stars of the same spectral class. Barring the possibility of systematic relative errors of spectral classification, Struve pointed out that the observations might mean either of two things: "Either the more luminous stars actually rotate more slowly than the less luminous stars, or the decrease in surface gravity due to rapid rotation simulates the absolute magnitude effect which was observed at Mount Wilson." If a star is rotating rapidly, the ionization in its reversing layer will be increased and the star will consequently be classified earlier—B8 or 9 instead of A0. Yet its effective temperature, proper motion, and parallax will all correspond to the lower luminosity of the normal (non-rotating) A0 star.

Stark effect broadens the lines in a manner different from Doppler broadening in a rotating star. Whereas the Doppler broadening is simply proportional to wave length ($\Delta\lambda = V\lambda/c$), the Stark broadening affects only certain series of lines (the appropriately named "diffuse" series). Moreover, in some series lines of shorter wave lengths may be broadened more than others of longer wave length. For example, λ 3872 of helium is widened more than λ 4922. The Stark broadening is greatest for dwarf stars, and so, incidentally, will enhance rather than counteract the broadening due to rotation. However, Struve remarked, "It is evident that the Stark effect can be used to discriminate between stars of high and low luminosity. This method has been successfully used for a number of stars, but in practice it is limited by the fact that

rotationally broadened lines fail to show the minor broadening of the diffuse helium series. . . The broadening of the hydrogen lines has for a number of years been tentatively attributed to Stark effect. Hulber, Vasnecov, and especially Russell and Stewart, have made computations showing that under the pressures believed to exist in stellar atmospheres, broadening of the Balmer lines should be observable. . . Since there are no lines of hydrogen devoid of Stark effect, and since there are no forbidden lines of hydrogen which make their appearance in the electric fields, it is impossible to make as convincing a test as was made in the case of helium. The observational evidence is therefore limited to the contours of the Balmer lines." And if measurements of line-contours are required to prove or evaluate the Stark effect in the stellar hydrogen lines, how well correlated are these effects with the simply visually estimated line-character or line-width criteria?

Hynek in 1936 reviewed three possible causes for lower luminosity in *n* than in *s* stars: 1) the already known possibility of systematic relative errors in classification; 2) the more luminous stars might rotate more slowly than the less luminous ones; and 3) there might be spurious absolute magnitude effects arising from a decrease in surface gravity in a rapidly rotating star, making it appear to belong to an earlier spectral class. The third hypothesis, suggested by Struve, had already been investigated by Emma T. R. Williams (*Ap. J.*, **82**, 432, 1935) who pointed out that it meant that the effective temperature of an A2n star, for example, should be lower than that of an A2s star. Having previously ascertained color equivalents for A-type stars, she showed that the average temperature of an A2n star is equal to that of an A5s, and, that the absolute magnitudes for the two are about the same. Similarly, for all sub-divisions from B9 to A5, agreement between the temperatures and absolute magnitudes in the *n* and *s* divisions could be achieved by a uniform relative displacement of three spectral sub-classes. Whence, Miss Williams stated, "It seems fairly safe to conclude, then, that the *n* stars do indeed show a higher level of ionization than they would show if they had no rotation." Hynek, however, found 1) that the luminosities of the *n* stars are nearly constant ($1^M.9$) for all the spectral sub-divisions B8-F8; 2) that the color differences between *n* and *s* vanish when Harvard classes are substituted for the Mount Wilson, a strong point against a rotational absolute magnitude effect; and 3) that the theoretical effect of rapid rotation investigated for a few of the lines in A-stars is so small that it would be difficult to detect except in rapidly rotating super-giants (which are not in question here). G. Shajn in a paper "On the Luminosity, Spectrum and Color of B and A Stars" (*Z.f.A.*, **13**, 132, 1937) similarly discussed the problems of *n* and *s* groups. He, however, disputes Hynek's contention that all *n* stars have the same absolute magnitude since this is not confirmed by stars in clusters.

Thus, many widely separated investigators appeared in agreement

that the sharpness of lines (in non-*c*-stars) was not a dependable criterion of absolute magnitude among the A-types. From some standpoints this is a satisfactory conclusion. A rapidly rotating star seen from a point in its extended equatorial plane would show wide hazy lines, whereas the same star seen from the direction of its polar axis would show sharp spectral lines. Spurious absolute magnitude effects (they are really classification effects) depending on rotation are possible but theory predicted that they should be small. Recent work, especially by Eggen (*Ap. J.*, **111**, 65 and 81, 1950) indicates that the dispersion of absolute magnitudes along the main sequence is negligible, except for the presence of several unique branch-sequences of peculiar stars lying close and to some extent more or less parallel to the average main sequence.

The correlations observed by Adams and Joy over twenty-five years ago nevertheless did have bearing on the determination of absolute magnitude. The Mount Wilson system of classification is internally consistent; on that system the line-quality criteria do indicate relative differences in luminosity. If indeed there is a unique one-to-one correlation between spectral class and absolute magnitude for either the normal main sequence stars or for stars of a given peculiarity, the line-character designations simply indicate the differential corrections from the provisional observed spectral classes to a "master" system (*e.g.*, the Draper system) which is more closely correlated with the colors of the stars.

In the light of the past attempts at correlating line-widths with absolute magnitude effects, it is of particular interest to note the distribution of rotational velocities among the stars belonging to the four discrete dwarf sequences discovered by Eggen (*loc. cit.*) from his photoelectrically determined color-magnitude arrays. Middle A through F-type stars fall into two sequences which he calls the "Bright Dwarfs" and the "Dwarfs." The stars belonging to the bright dwarf sequence show higher rotational velocities than do those of the ordinary dwarf sequence, contrary to expectation based on early Mount Wilson results. On the other hand, among the bluer Pleiades stars, where Eggen found the two additional sequences which he calls the "Bright Blue Dwarfs" and the "Blue Dwarfs," the situation is reversed, the fainter dwarfs showing the higher rotational speed—in this case in qualitative agreement with the Mount Wilson conclusions on *n* and *s* groups.

At Other Observatories

While Adams and his collaborators at Mount Wilson were advancing the art and technique of spectroscopic absolute magnitude determination, and testing the physical basis of the empirical results they were able to find, other observatories had also taken up the quest. Table V gives references to most of the lists of spectroscopic absolute magnitudes or parallaxes that have been published, together with notes on the types of criteria used and the principal sources of calibration. For

TABLE V (First Part)

Observatory	Authors	References	Sp.	No.	A/mm	Inst.*	Criteria	Measurements	Chief Calibration Material
Harvard	H. Shapley, B. Lindblad	*H.C.*, 228, 1921	G7-K3	50	45	O	Relative line intensities; Cyanogen	Eye-estimates	Mt. W. Spectroscopic (Mt. W. Contr. 199)
Harvard	H. Shapley, M. B. Shapley	*H.C.*, 232, 1922	G7-K3	87	45	O	Relative line intensities	Eye-estimates	Mt. W. Spectroscopic
Harvard	H. Shapley, A. Ames	*H.C.*, 243, 1923	K0	233	45	O	Relative intensity 4215:4326	Eye-estimates	Proper motions (Eddington-Douglas formula, *M.N.*, **83**, 112, 1923)
Harvard	H. Shapley	*H.C.*, 246, 1923	G5-K5	116	45	O	Same	Same	Same
Lockyer	W. B. Rimmer	*Mem. R.A.S.*, **62**, 4, 1923	F0-Mb	500	36	O	Relative line intensities	Photographic Wedge	Trigonometric parallaxes
Victoria	R. K. Young, W. E. Harper	*D.A.O.*, **3**, 1, 1924	A-M	1105	29	S	Same	Artificial scales	Astrometric data
Lockyer	W. B. Rimmer	*Mem. R.A.S.*, **64**, 1925	F0-Mb	525	36	O	Same	Photographic wedge	Same
Stonyhurst	H. Macklin	*M.N.*, **85**, 444, 1925	F8-K3	30	60-80	S, O	Same	Same	Mt. W. Spectroscopic
Yerkes	A. V. Douglas	*J.R.A.S.C.*, **20**, 265, 1926	B9-F0	200	33	S	Relative line intensities. Widths hydrogen lines	Eye-estimates Gaertner machine	Trigonometric and clusters
Harvard	D. Hoffleit	*H.A.*, **105**, 45, 1937	A5-M	377	45	O	Relative line intensities	Eye-estimates	Astrometric data
Yerkes	P. Keenan	*Ap. J.*, **91**, 506 1940	G5-K5	266	100	S	Same	Same	Trigonometric parallaxes
Harvard	D. Hoffleit	*H.C.*, 448, 1942	M	313	45	O	Relative line intensities	Eye-estimates	Astrometric data
Harvard	D. Hoffleit	*H.C.*, 449, 1943	G8-K2	365	45	O	Same	Same	Same
Harvard	D. Hoffleit	*H.A.*, **119**, No. 1, 1950	A3-G2	500	45	O	Same	Same	Same

TABLE V (Second Part)

Observatory	Authors	References	Sp.	No.	A/mm	Inst.*	Criteria	Measurements	Chief Calibration Material
Lockyer	D. L. Edwards	*M.N.*, **83**, 47, 1922	B0-B5	49	36	O	Intensity differences	Photographic optical wedge	Hypothetical parallaxes; group motions
Lockyer	D. L. Edwards	*M.N.*, **84**, 366, 1924	B0-B9	100	36	O	Same	Same	Trigonometric; moving cluster
Arcetri	G. Abetti	Arcetri Pub., 41, 1924	B8-F6	159	90	O	Line widths		Previous spectroscopic; trigonometric
Arcetri	G. Abetti	Arcetri Pub., 42, 1925	B5-G0	275	90	O	Same		Same
Lockyer	D. L. Edwards	*M.N.*, **85**, 439, 1925	B0-B8	100	36	O	Intensity differences	Photographic wedge	Trigonometric; moving clusters
Lockyer	D. L. Edwards	*M.N.*, **87**, 364, 1927	B0-B9	300	36	O	Line character	Eye-estimates	Parallactic motion; moving clusters
Lockyer	H. C. Woods	*M.N.*, **87**, 387, 1927	A0-A5	300	36	O	Same	Same	Trigonometric; group motions
Lockyer	D. L. Edwards	*M.N.*, **88**, 175, 1928	B0-B9	125	36	O	Intensity ratios line character	Optical wedge eye-estimates	Parallactic motion; moving clusters
Lockyer	D. L. Edwards	*M.N.*, **90**, 523, 1930	B0-A0	175	36	O	Line character	Comparison with standard negatives	Parallactic motion; moving clusters
Mt. Stromlö	W. B. Rimmer	*Mem. Comm. Solar Obs.*, **2**, 1930	B0-A0	350	17	O	Same	Eye-estimates	Same
Lockyer	E. S. Williams, D. L. Edwards	*M.N.*, **98**, 467, 1938; *Comm. N. L. O.*, 43	B0-B9	45	35	O	Line width	Photographic (triangular) wedge	Parallactic motion; galactic rotation

TABLE V (Third Part)

Observatory	Authors	References	Sp.	No.	A/mm	Inst.*	Criteria	Measurements	Chief Calibration Material
Harvard	C. J. Anger, C. H. Payne	*H.C.*, 363, 1931	B0-A3	108	45	O	Hydrogen intensities	Scale of Comparison spectra	Group motions (Scorpio-Centaurus)
Harvard	E. Öpik, M. Olmsted	*H.C.*, 369, 1931	B5-A5	107	45	O	Same	Artificial Comparison scale	Proper motions
Harvard	C. J. Anger	*H.C.*, 372, 1932	O-A0	170	45	O	Same	Scale of Comparison spectra	Moving clusters
Harvard	C. J. Anger	*H.C.*, 373, 1932	O-A0	239	38-400	O	Same	Same	Same
Harvard	E. Öpik, M. Olmsted	*H.C.*, 380, 1932	O-A5	792	45	O	Same	Artificial Comparison scale	Proper motions and radial velocities
Victoria	R. M. Petrie, C. D. Maunsell	*D.A.O.*, **8**, No. 8, 1950	B8-A3	169	11-51	S	Same	Microphotometer tracings	Trigonometric, dynamical, spectroscopic, cluster parallaxes.

*O, Objective Prism
S, Slit

the A and B-type stars, whose trigonometric parallaxes are for the most part as small as their probable errors, most investigators sought absolute magnitude data on individual stars by studying the spectra of the stars in open or moving clusters, to supplement the calibration material available from the statistical results derived from proper motion data.

Table V is divided into three parts depending on the predominant type of criterion that has been adopted. The first part contains references to those determinations dependent chiefly on ratios of line intensities. In the second part, the authors follow Adams and Joy in the use of the sharpness or width of the lines; while the third part refers to the determinations based on the total intensities of the hydrogen lines in the early-type stars. The results in the third part, more than the others, depend on microphotometer tracings or comparisons of the spectral lines with some sort of scale, either artificial or a group of spectra of selected comparison stars.

Several types of results derived from stellar spectra are not included in this Table:

1. Those depending on spectrophotometric criteria, such as the relative density gradients or the cyanogen criterion—the methods developed by Lindblad and his associates and extensively employed by the Swedish astronomers, by Friedrich Becker and others.

2. The density-gradient method proposed by Ch'ing-Sung Yü at Lick in 1926 (L.O.B. 380) for determining the absolute magnitudes of A-type stars from the continuous hydrogen absorption.

3. The method proposed by Payne and Howe (*H.C.*, 287, 1925) on the basis of indications given by W. H. Wright (*Nature*, **109**, 810, 1920), and subsequently discussed further by Unsöld and Struve (*Ap. J.*, **91**, 365, 1940), Miczaika (*Z.f.A.*, **25**, 268, 1948) and Udo Becker (*Z.f.A.*, **26**, 7, 1949), for determining absolute magnitudes from the principal quantum number of the highest perceptible member of the Balmer series.

4. The catalogues that simply differentiate between supergiants, giants, and dwarfs, like the Spektral Durchmusterung catalogues issued at Potsdam and Bergedorf.

5. The important results of W. W. Morgan and others giving "luminosity classes" which serve as a code for absolute magnitudes within each spectral class. For those spectral sequences around which the dispersion in absolute magnitude is small, these luminosity classes may be considered as "uncalibrated" absolute magnitudes which may have higher precision than the reduced numerical values would have, since they do not yet include the errors in the calibration data as such. E. G. Williams, for example (*Ap. J.*, **83**, 305, 1936) calibrated similar luminosity classes for B-type stars, assuming zero dispersion within each subclass and luminosity group. So long as "peculiar" stars are recognized and either excluded, or treated separately from the calibrations of the bulk of the stars, there are indications that the luminosity classes may define the absolute magnitudes in a given spectral sub-division more accurately than do the estimates of individual line-intensities or intensity-ratios.

6. Absolute magnitudes dependent on interstellar lines, the method discovered by Struve (*M. N.*, **89**, 576; *Ap. J.*, **67**, 353, 1929).

Of the results summarized in Table V, those in the first and third parts represent the methods that have been accepted as reasonably dependable within the observational limitations. On the other hand, those in the second part, most of which were based on the width of the hydrogen lines, while always "promising," have (as we have already seen in

the case of the Mount Wilson material), for the most part, been subject to more controversy than the others. Thus, in the 1925 *Transactions* of the International Astronomical Union (Vol. 2, p. 76) Shapley had stated, "A considerable investigation of the determination of the parallaxes of blue stars, using as criteria the widths of the absorption lines, has ended in the conclusion that this method, which has already been used at Mount Wilson and Arcetri, is of low value." While considerable variation in the line-widths in spectra of class A had been observed, it was not closely correlated with absolute magnitude except in the stars showing the *c*-characteristic. This was later confirmed by Rudnick (*Ap. J.*, **83**, 439, 1936), who, classifying B stars both according to line-character and luminosity groups, found examples of both *n* and *s* characteristics among dwarf stars of the same spectral subclass. But Shapley's opinion was not shared by G. Abetti, who, in 1919, had independently discovered that the widths of the hydrogen lines and calcium bands were correlated not only with spectral class but with absolute magnitute as well. Although he did concede, in the face of Shapley's criticism, that the indicated absolute magnitudes should be "considered as approximate only" *Trans.; I.A.U.*, **2**, 75, 1925), he did, on the other hand, contend that Lindblad's interpretation of the absolute magnitude effects between *n* and *s* spectra found at Mount Wilson "is not borne out by the results found here," *i.e.*, at Arcetri.

Subsequent to these discussions, D. L. Edwards at the Norman Lockyer Observatory nevertheless continued to apply precisely these criteria to the determination of the luminosities of the early-type stars. Appreciating the significance of the Lindblad and Fairfield criticisms of the Mount Wilson results for the A-type stars, Edwards investigated to what extent they might also apply to the B-types. He found that the Harvard and Mount Wilson spectral classes of B0-B9 stars agree very closely, and that there is no real difference in classification between the *n* and the *s* divisions. On the other hand, the mean difference between the absolute magnitudes of the two categories determined from group-motion parallaxes, is both significant and appreciable. Hence, he stated, "It would seem that there is some ground for believing in the reality of the relation between line character and absolute magnitude for these stars" (*M. N.*, **87**, 365, 1927). The absolute magnitudes he then derived by applying the line-character criterion, he found to be in good agreement with magnitudes based on intensity-ratios (*e.g.*, *M. N.*, **88**, 179, 1928). The correlation he obtained is shown in Figure 6, where the numbers adjacent to the individual points indicate the Henry Draper sub-class (all B-type stars). Here it is seen at once that the major part of the correlation between M_1 and M_2 depends on spectral class, the brightest magnitude corresponding to B0, the faintest to B5. The criteria, besides line-character, used for the determination of the absolute magnitudes, were the ratios of the intensities of the helium lines 4388, 4144, and 4471 to the hydrogen lines. However, in 1924 Cecilia Payne

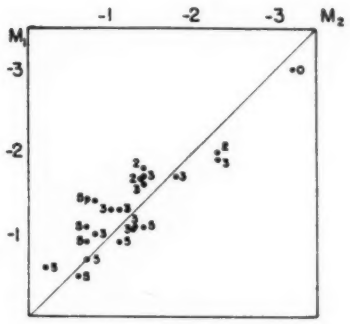

FIGURE 6

After Edwards, *M. N.*, **88**, 179, 1928. M_1 depends on intensity ratios, M_2 on line character.

had already pointed out with reference to Edward's earliest results (*M. N.*, **83**, 47, 1922), that absolute magnitudes so determined are "based on untenable spectroscopic principles" (*Nature*, **113**, 783, 1924). The criteria used for spectral classification were the 1π-mδ lines of helium. The 1P-mD lines that Edwards employed as absolute magnitude criteria "show intensity changes identical with those of the 1π-mδ lines." Hence, the correlations found with the absolute magnitudes were really only "the well-known statistical correlation of type and luminosity in B stars."

Following Edwards, W. R. Rimmer at the Commonwealth Solar Observatory at Mount Stromlö, Canberra, Australia, in 1930 also applied line-character criteria to the determination of absolute magnitudes of B-type stars, obtaining conspicuous differences, especially among the later B-types, between the absolute magnitudes corresponding to six different line-character groups. In this list, the relation between Rimmer's and the Henry Draper spectral classes is the same for all line-character groups. If the dispersion of the absolute magnitudes is spurious it must therefore be attributed to some other cause than relative errors in classification. Anger and Payne at Harvard (*H.C.* 363, 1931), determining luminosities from total hydrogen absorption, found a fairly good correlation between theirs and the absolute magnitudes determined by Rimmer. When, however, their material is subdivided according to spectral sub-types, it is apparent that this correlation is again primarily the same statistical trend of luminosity with type. Among the earlier types there is some residual correlation of the two determinations of absolute magnitudes, but the dispersion of the Harvard values is much the larger (Table VI).

The results obtained recently at Victoria by Petrie (*D.A.O.*, **8**, No. 8, 1950) using carefully measured microphotometer tracings for determining total hydrogen line intensities, show no conspicuous correlation

TABLE VI

Spectrum	Rimmer	Av. Harvard	n	Average ± Standard Deviation Rimmer	Harvard	n
B3	−1.9	+0.8	1	−0.9 ± 0.3	−0.4 ± 1.0	19
	−1.0	−1.1	9			
	−0.7	−0.2	7			
	−0.4	+1.3	2			
B8-9	−0.1	+1.4	1	+0.3 ± 0.2	+1.4 ± 0.3	9
	0.0	+1.2	1			
	+0.3	+1.2	2			
	+0.4	+1.8	3			
	+0.6	+1.3	1			
	+0.7	+1.0	1			

with Rimmer's values for the fifteen stars they have in common, even though all degrees of sharpness are represented among the fifteen stars. Likewise, six of the stars on Rimmer's list are Pleiades whose photoelectric colors and absolute magnitudes have recently been measured by Eggen (*loc. cit.*). Although the sample is too small to yield significant differences, the absolute magnitudes are again contradictory, whereas Petrie's and Eggen's results do show a marked correlation with one another. An unpublished reclassification by Hoffleit and de Jonge of some thousand B8-A3 spectra at Harvard, preliminary to an investigation of luminosities and spectral peculiarities, includes only 55 of the stars studied by Rimmer. For the majority of these no abnormalities were recorded; the peculiarities provisionally noted for sixteen of these stars have the following distribution:

Peculiarity	Rimmer's Line-Character Group
5 Silicon stars	2 s′, 3 s
6 Luminosity class I or II	1 ss, 1 s′, 2 s, 2? ns
3 Showing hydrogen lines only	2 ns, 1 n

Except for showing that silicon as well as high-luminosity stars tend to show sharp lines, these available data as yet shed little additional light on the meanings of Rimmer's six proposed luminosity classes. The 55 stars common to Harvard and Rimmer have an approximately random distribution about the average of Rimmer's six line-character groups, as is indeed the case for all the stars in Rimmer's catalogue (Table VII).

TABLE VII

Group	ss	s′	s	ns	n	nn
309 stars classified by Rimmer	44	41	100	93	28	3
55 stars classified by Hoffleit and de Jonge	2	8	15	19	10	1

The absolute magnitude estimates based on line-widths made prior to 1931 thus encourage little confidence in the dependability of the method. However, the most recent published determinations based on this criterion are those of E. G. Williams and Edwards at the Norman Lockyer Observatory (*M. N.*, **98**, 467, 1938; *Comm. N.L.O.* 43). The purpose of their investigation was to find criteria that could be applied by simple visual inspection of unstandardized spectra. For estimating the line

widths the authors were apparently more painstaking than their predecessors. They constructed a pair of photographic wedge-shaped scales and were particularly careful about plate illumination. They found that "the wing width correlates reasonably well with the ratio (total absorption)/(line width) derived from the photometric intensities, which measure of line width turns out to be a good index of luminosity. Certainly for hydrogen it is a better one, in the earlier types at least, than the total absorption alone." The diagrams presented by the authors in demonstration of this conclusion showed only comparisons between their own results and the corresponding Mount Wilson values, separately for spectral class and for absolute magnitude; and similar correlations between their own estimated and measured quantities. In Figure 7

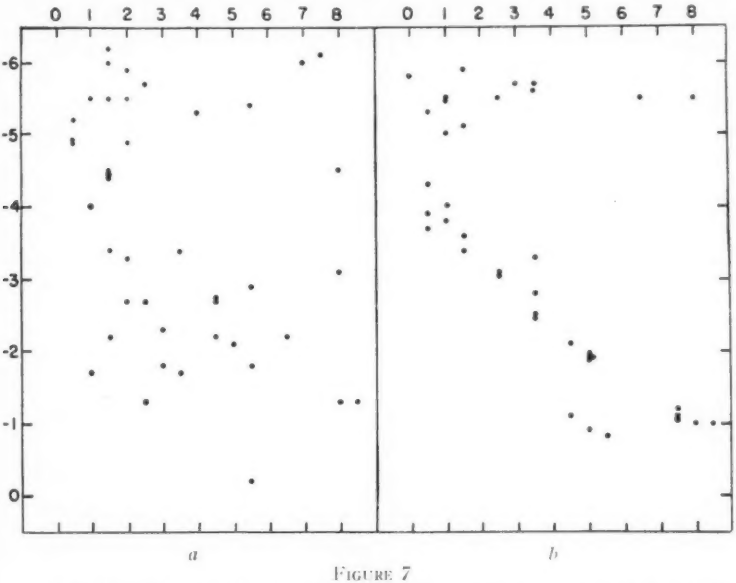

FIGURE 7

Data from *Comm. N.L.O.* 43. Ordinates are absolute magnitude, abscissae, decimals of spectral type.

their results are now presented in pseudo Russell-diagrams. The first plot gives Williams' types and magnitudes depending on estimates utilizing the photographic wedge, while the second part shows the results dependent on actual spectrophotometric measurements. Whereas the estimated quantities show considerable dispersion, the measured quantities show two very clearly defined sequences: the main sequence and a supergiant sequence of almost constant absolute magnitude of —5.5. Only four stars deviate prominently from these two sequences, one (6 Lacertae) at "type 3.5," M = —3.3, and three that lie about one

magnitude below the main sequence (η Aurigae, η Ursae Majoris, and 12 Vulpeculae, all B3 stars). Do these deviating stars possibly represent a special sequence; or do they simply represent large accidental errors? When H. D. classes are substituted for either the estimated or the measured types, the scattering becomes intermediate between that of the two presented diagrams, accounting, perhaps, for the author's conclusion that their estimated and measured values are about equally good (*i.e.*, in comparison with determinations at other observatories). This implies that much of the scattering in Figure 7*a* is due to the spectral types, which depend on averages of intensity ratios while Figure 7*b* seems to indicate that, within a specific luminosity class, the measured criteria in the two coordinates are uniquely correlated, a simple two-dimensional spectral class being sufficient to define absolute magnitude. From this one might conclude that the criteria chosen for absolute magnitude determination are in some instances superior for classification purposes to the original criteria chosen for the explicit purpose of placing a star in its correct position in the spectral (*i.e.*, temperature) sequence. The results shown in Figure 7*b* bear comparison with Eggen's recent work on open clusters. The particular arrays indicated in Figure 7*b* do not correspond to those found by Eggen in the Pleiades, which are all for later spectral classes than those of the stars measured by Williams and Edwards. It is, however, of interest to note that the curve for Eggen's blue dwarfs, relating color index with absolute magnitude, becomes very steep for his bluest stars (corresponding to spectral class B6), there being no change of color corresponding to a change in absolute magnitude from 0 to —3. This is close to the red limit represented in Figure 7*b*, where the three discrepant observations are found.

The Resolution of the Russell-Diagram

The Russell-diagram for the most recent Mount Wilson list (*Ibid. Mt. W. Contr.* 511, 1935) shows four main classes of stars: supergiants, giants, sub-giants, and main-sequence or dwarf stars. A few subdwarfs (Spectrum A4-9; M, 4.7-5) are also included, but no white dwarfs. The dispersion in the main sequence, or in the giant sequence, for a given spectral sub-class was found to be of the order of $\pm 0^{M}.4$, the same order of magnitude as the discrepancy between the spectroscopic and the trigonometric results. In fact this result foreshadows the conclusion reached in Eggen's subsequent investigations which implies negligible scattering in the absolute magnitudes along any of the sequences found for cluster stars. But the apparent conclusion from the Mount Wilson results was almost immediately questioned and searchingly investigated, Russell and Moore and van Rhijn independently reaching the conclusion that the real dispersions in the absolute magnitudes are some 40% greater than the dispersions in the spectroscopic determinations. The cause for this discrepancy was attributed to the fact that only the one regression curve giving the mean absolute magnitude for a given line-intensity had been used in deriving calibra-

tion curves; whereas it was contended that the mean between this and the other regression line, giving mean line-intensity for a given absolute magnitude, should have been employed.

The relations found photoelectrically by Eggen (*loc. cit.*) between absolute magnitudes and colors of stars in the Hyades and Pleiades is shown schematically in Figure 8. The approximate spectral classes cor-

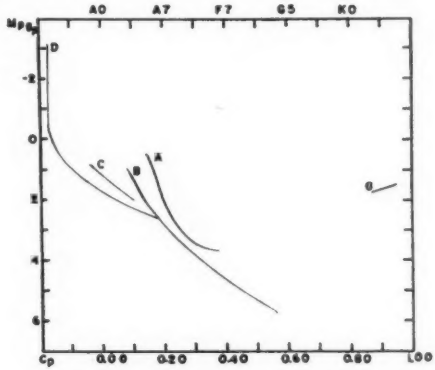

FIGURE 8

After O. Eggen, *Ap. J.*, **111**, 89, 1950. A, bright dwarfs; B, dwarfs; C, bright blue dwarfs; D, blue dwarfs; G, giant.

responding to his color indices are given at the top of the diagram. If the various sequences were equally populated, the standard deviation of any point from the mean would not be inconsistent with the actual dispersion found in the Mount Wilson spectroscopic absolute magnitudes. Eggen's diagram recalls a searching discussion by Öpik (*H.C.* 369. 1931), particularly in relation to early-type stars, on the possibility of observing a single major sequence having a fairly uniform dispersion (see Figure 9) when in reality the apparent sequence is composed of numerous short, relatively independent arrays which are caused to overlap primarily through the operation of accidental observational errors or cosmic effects, such as interstellar absorption. To date the work on photoelectric colors has resolved into discrete sequences the apparent absolute magnitude dispersion only along the main sequence for stars between spectral classes B7 and G5. In each of these component sequences the maximum deviations are within $\pm 0^{M}.1$. Will further accurate measurements also resolve the giant sequence and the redder members of the main sequence into component sequences having essentially zero absolute magnitude dispersion? Will the separations of the component sequences be such as to account for the composite dispersion found from the Mount Wilson spectroscopic absolute magnitudes to be $\pm 0^{M}.4$, and increased by some 40% through the statistical analyses of Russell

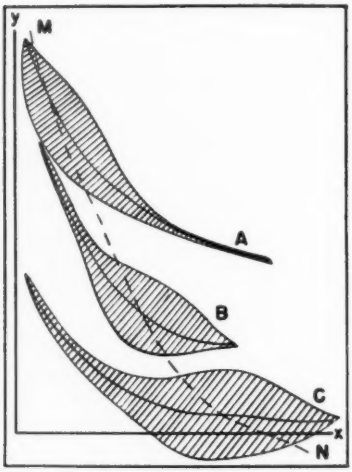

FIGURE 9

From H.C. 369—"Showing how several independent correlations A, B, C . . . for different groups of objects (spectral types), treated together, may give an apparent general correlation MN, determined as the geometrical locus of maximum frequency, and differing noticeably from the individual curves. The frequency of points along the curves is indicated by the width of the cross-hatched areas."

and Moore (*Ap. J.*, **92**, 354, 1940; *Mt. W. Contr.* 636) and van Rhijn (*Groningen Pub.* 49, 1939)?

And what about the supergiant stars that heretofore have not fallen into any very well-defined sequences on the Russell-diagram? As yet the calibration data for the supergiants are more uncertain than for any other classes of stars. The most promising data for analysis in the near future would appear to be forthcoming in the Magellanic Clouds. If a constant distance modulus is assumed, the thickness of a Cloud might introduce a spurious absolute magnitude dispersion of only one or two tenths of a magnitude. Obscuration will be a more significant obstacle, but apparently heavily obscured regions can be rejected. The apparent magnitude limit, 13^m, for the spectra already classified by Miss Cannon in the Large Cloud (*H. A.*, **100**, 208, 1936), corresponds to a faint absolute magnitude limit of about -4^M. Consequently all of the stars in the Cloud whose spectra have already been classified are very high-luminosity supergiants. From a comparison of the frequencies found in the area of the Cloud and a nearby comparison field (charts 1-9, *H. A.*, **112**, 1949), however, it would appear (Table VIII) that only the O- and B-type stars, and perhaps half of the M-types classified, are actual members of the Cloud; and from these, little can be said about the possibility of their alignment into sequences. From an apparent magnitude-spectrum array one might at best risk the suggestion that

there are two classes of O-stars, one group having a mean absolute magnitude of —5.5 the other —3 or fainter (see Hoffleit, *H. B.*, **892**, 1933). Hence, for the analysis of the luminosity-spectral class distribution of supergiants from Magellanic Cloud data, an apparent magnitude limit of at least 16^m will be necessary.

TABLE VIII

Spectral Class	O	B	A	F	G	K	M
N_1 Large Magellanic Cloud	23	132	93	363	505	548	66
N_2 Comparison Field	0	0	80	810	1055	806	37

What bearing do all of these studies have on the discovery by Baade (*Ap. J.*, **100**, 137, 1944) of two discrete stellar populations? By far the greatest majority of all the spectra discussed here belong to Population I, including those in open clusters and the Magellanic Clouds. For the most part stars of Population II will either be apparently faint because of their distance from the sun, or comparatively scarce in the case of those more nearby members that will be found to lie in the sparsely populated regions between the spiral arms of our own galaxy. It may well be, however, that many of the stars that at present do not appear to fall on fairly well-defined sequences are members of Population II. As the most reliable members of this population have thus far been found in globular clusters or in the Andromeda nebula, it is evident that the absolute-magnitude-spectral class array for Population II has been determined only for the brighter half of the "Russell-diagram." Inasmuch as other discriminators for the distances of individual stars (non-cluster members) will not reach stars as remote as a sufficiently representative sample of Population II, spectroscopic luminosity criteria must eventually play a major role in the determination of the characteristics of the new diagram for galactic stars. The completeness of discovery of the general characteristics of the "Russell-diagram" for Population II is now at about the same stage as were Hertzsprung's results over forty years ago, when he first discovered the dwarf and supergiant stars in what is now known as Population I.

HARVARD COLLEGE OBSERVATORY.

On the Star Pictures which First Marked the Seasons*

By C. C. WYLIE

1. The constellations which marked the beginnings of the seasons for the early people who laid out our present star pictures were, for spring, Taurus the Bull or ox; for summer, Leo the Lion; for autumn,

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Scorpius the Scorpion; and for winter, Aquarius the Water Bearer. Taurus was pictured as charging at Orion, the mighty hunter. Evidently the Bull was not the tame domestic animal, but the untamable wild ox, a powerful and ferocious animal said to be more formidable than the lion.

2. Early people naturally came to use these most important sky pictures as symbols on their banners and coins; but the Scorpion was not liked as an animal, so two nearby constellations, Aquila, the Eagle, and Serpens, the Serpent, were submitted. The popular figures therefore came to be the Ox, the Lion, the Eagle, and the Man.

3. Perhaps the best known use of these sky pictures as symbols is that by the Children of Israel. The four principal tribes of Israel were Judah, Reuben, Ephraim, and Dan. The banners or standards carried according to tradition were, by Judah a lion, by Reuben a man beside a river, by Ephraim an ox, and by Dan an eagle and a serpent.

4. Scripture does not describe the figures on these standards, but certain passages show that these figures were associated with the tribes mentioned, or with Israel as a whole. References to Joseph should be interpreted as applying to Ephraim, the son of Joseph. "Judah is a lion's whelp . . . he couched as a lion." "The Lion that is of the tribe of Judah." Reuben is "boiling over as water." (Douay version, "poured out as water.") "Dan shall be a serpent." Joseph's "horns are the horns of the wild ox." Joseph's "branches run over the wall." The Hebrew word for "branches" might be translated "daughters," and that for "wall" might be translated "bull," so this passage has been translated Joseph's "daughters walk upon the bull." Simeon and Levi "hocked an ox." An old Jewish version expands this passage to, Simeon and Levi "sold Joseph their brother who is likened unto an ox." (Joseph, as ruler of Egypt, bound Simeon, implying that Simeon was the leader in selling Joseph.)

5. Other passages associate these figures with Israel as a whole. "As a lion doth he (Israel) lift himself up." Israel "lay down as a lion." Israel "hath as it were the strength of the wild ox." "Water shall flow from his (Israel's) buckets."

6. The Israelites favored the figures of these sky pictures much more than others for drawings and images. While the Children of Israel were in the wilderness, Aaron made a golden calf, and Moses made a brazen serpent. The temple of Solomon showed drawings of many lions, oxen, and Cherubim. Twelve large brazen oxen supported the molten sea in front of the temple. Following the death of Solomon, Jeroboam, an Ephraimite, set up two golden calves for the northern kingdom. Still later, Hezekiah broke in pieces a brazen serpent which the Jewish people were worshipping.

7. Ezekiel, who no doubt was familiar with the drawings of Cherubim in the temple, saw in a vision what he knew were Cherubim. According to this vision a Cherub was a winged creature with four faces,

the four being the face of a man, the face of a lion, the face of an ox, and the face on an eagle. St. John saw in a vision four living creatures, the first "like a lion," the second "like a calf," the third "had a face as of a man," and the fourth was "like a flying eagle."

8. The preceding scriptural passages refer repeatedly to the ox, which marked spring. Some of the earliest passages specify the wild ox, agreeing with the sky picture of a big game animal. Also the passage "the daughters walk upon the bull" seems an obvious reference to the Pleiades or "seven sisters" pictured on the shoulder of the Bull.

9. The Lion, which marked summer, is appropriately associated with Judah, the strongest tribe. The Eagle and the Serpent were thought of by early people as together marking autumn, and both figures are mentioned in the scriptural references.

10. Aquarius was pictured as a man pouring water from a vessel. The otherwise meaningless passage "water shall flow from his buckets," seems to be a reference to this sky picture of pouring water.

11. We have found that the four faces of the Cherubim and the figures said to have been shown on the banners carried by the four principal tribes of Israel agree exactly with the figures of the star groups marking the four seasons for these early people. Even certain details of these four star pictures are in agreement with Scriptural references.

12. The Israelites were, of course, not the only early people who used these star pictures as symbols, and once the figures of these pictures had come into general use, later nations adopted them even though they no longer marked the seasons. For example, the Romans of classical times used lions, bulls, and eagles on their coins.

13. An important use of these figures has always been on standards carried by the armies. The wild ox, lion, and eagle are appropriate, since they are ferocious fighting creatures. Neither the serpent, nor the man pouring water, is so appropriate for that purpose so these figures were generally dropped. Further, the ox on the standard came to be interpreted as the tame domestic animal; and the tame ox is as different from the wild ox as the pussy cat is different from the wild cat. Soldiers do not mind being called lions or eagles, but they do object to being called cattle or pussies. So today we find the bull, or ox, formerly marking spring and on the banner of Ephraim, sacred in India, but used hardly at all by the nations of Europe and the Americas. The lion, formerly marking summer and on the banner of Judah, is used by Great Britain, Norway, Sweden, and many other nations. The eagle, formerly marking autumn and on the banner of Dan, is used by the United States, Germany, Austria, Chile, and other nations.

14. The eagle on modern American coins is very similar to the eagle shown on coins of old Roman times. Mexico, rather interestingly, uses both the eagle and the serpent, exactly the sky pictures marking autumn, and said to have been used on the banner of Dan. The serpent is not much used as we have said; but there is one use common in America.

The sign of the physician, the Caduceus, is a winged cane with two serpents coiled about it. Serpents have long been associated with the medical profession, for the sky picture dating from some 5000 years ago shows a giant physician holding the serpent.

15. Thus we have found that the figures said to have been on the banners of the principal tribes of Israel are exactly the sky pictures which marked the four seasons for people living 3000 to 5000 years ago. These same figures were used for the four faces of the Cherubim in the Temple. The sacred Bull of India, the Lion of Great Britain, and the Eagle of America are all descended from these same constellation figures.

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Scripture references are to American Revision

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3. Gay and Adams, "Biblical Encyclopedia," p. 358; Crommelin, *Op. cit.*, p. 662; Numbers II, 3-31.
4. Genesis XLIX, 9; Revelation V, 5; Genesis XLIX, 4, 17; Deuteronomy XXXIII, 17; Genesis XLIX, 22, 6.
5. Numbers XXIII, 24; XXIV, 9, 8, 7.
6. Exodus XXXII, 1-6; Numbers XXI, 8-9; I Kings VII, 29, 36, 25; XII, 28-29; II Kings XVIII, 4.
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UNIVERSITY OF IOWA, IOWA CITY, IOWA.

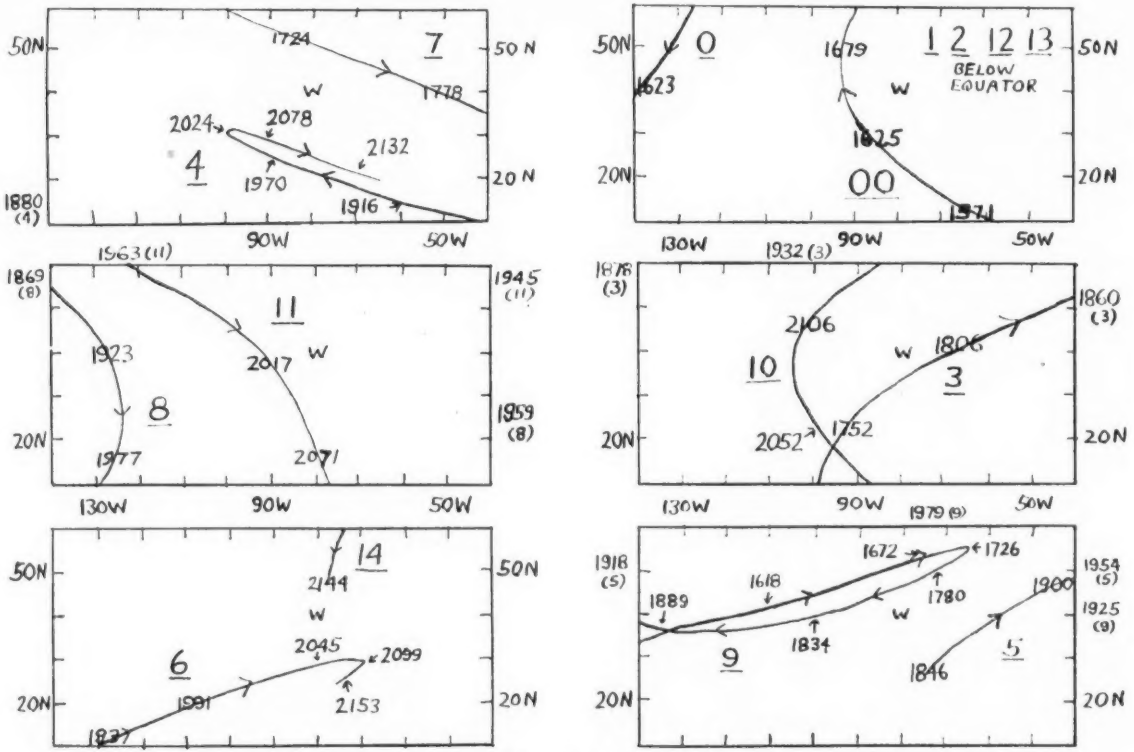
Recurrence of Total Solar Eclipses

By RAYMOND M. BELL

One of the most interesting facts about solar eclipses is their recurrence after a period of 18.039 tropical years (the saros). Of even more interest is the return after 54.117 years of the eclipse in the same general region. This is due to the fact that after 18 years the eclipse reappears 120° west in longitude. It takes 54 years to complete 360°.

During the period from 1650 to 2150 A.D. there are 16 series of eclipses, 12 of which occur within the general region of the United States: 10° N to 60° N latitude; 40° W to 140° W longitude.

If the places where the eclipses are central and total at local noon at 54 year intervals are connected for each series, the results are as shown in the figures. (W represents Washington, Penna., approximately 40°



CHARTS SHOWING TOTAL SOLAR ECLIPSE LOCATIONS

N and 80° W.) The series are numbered from 00 to 14. Numbers 1, 2, 12, 13 are in the southern hemisphere. 00 and 0 disappeared in 1733 and 1768. 3 reached the top of its path in 1932. 14 has not yet appeared.

Only 4, 5, 6, 8, 9, 11 will have total eclipses in the region shown between 1950 and 2050.

4: 1970, 2024
5: 1954
6: 1991, 2045
8: 1959, 1977
9: 1979
11: 1963, 2017

It is interesting to note the behavior of these series. 00, 3, 5, 10 are moving northward. 0, 7, 8, 11, 14 are moving southward. 4, 6, 9 reverse their directions, thereby contributing a large number of eclipses. The eclipse series advance north or south until they reach a pole, ending the series; or they may end as an annular eclipse as 0 did in 1768.

Since a series may last 1250 years, for a short period such as 500 years the distribution of eclipses is not uniform. The region between 20° and 30° N latitude and 60° and 100° W longitude, centering on Florida, has 32% of the eclipses instead of 8%. Other regions have no eclipse centers in 500 years.

No eclipse has been total in the vicinity of Washington, Penna., since August 13, 1151.

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Washington and Jefferson College, Washington, Pa.

Contributions of the Meteoritical Society

Edited by FREDERICK C. LEONARD
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Observations on the Toluca, Mexico, Meteoritic Iron (ECN = +997,194)*

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Abstract

An interesting fragment of the Toluca, Mexico, sideritic shower (ECN = + 997,194) is described. It is interesting from the viewpoint of the concentration of minor meteoritic constituents in abundance and from the viewpoint of structure. The principal constituent is kamacite,

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†Research Associate, Institute of Meteoritics, University of New Mexico.

but the fragment contains macroscopically visible schreibersite, graphite, troilite, daubréelite, and lawrencite. One (1) figure and 4 tables are given.

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1. *Introduction.*—The Toluca, Mexico, meteorite (ECN = + 997,194) has been described by many writers. Farrington (1915) gives the most complete data on the history, description, chemical analyses, references, *&c.* of the Toluca meteorite from the time of the first printed record of the meteorite (1784) up to 1909.[1] Since that time, many papers have appeared, devoted to special studies of this meteorite. It is the purpose of this paper, not to repeat work by earlier writers, but to present some observations on an unusual fragment of the Toluca meteoritic iron.

2. *Macroscopic Examination.*—The specimen of the Toluca siderite examined in this report bears the registration number "IOM-3" in the Institute of Meteoritics collection. The specimen weighs 28.6 gm., has a specific gravity of 6.24 (Jolly balance), and has maximum dimensions measured in 3 directions at right angles to one another of $25 \times 17.5 \times 15.9$ mm. The exterior crustal surface is rusty brown to black and exhibits several fractures penetrating into the interior of the meteorite. The oxidation crust has an average thickness of 0.2 mm. and penetrates into the interior of the meteorite along the fractures.

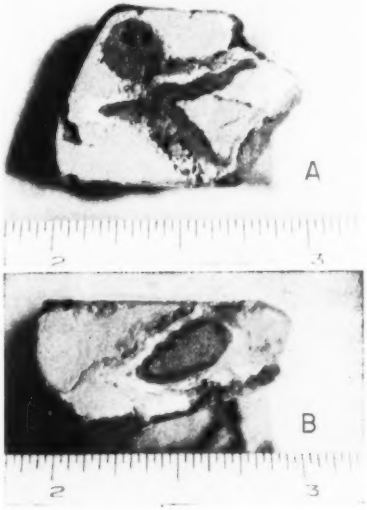

FIG. 1
TWO VIEWS OF THE TOLUCA, MEXICO, METEORITIC IRON (SEE TEXT FOR EXPLANATION). SCALE IN INCHES

The fragment has been sawed along 2 planes at right angles to each other, and the sawed surfaces have been polished. The result is the 2 striking photographs of Fig. 1. In Fig. 1A the light-gray material is structurally homogeneous kamacite. After etching with Nital, the kamacite is seen to consist of irregular, elongated bands, 3-4 mm. wide and up to 15 mm. in length; these bands exhibit the characteristic oriented sheen that changes when rotated. The kamacite contains no Neumann lines. No taenite is evident; therefore, the nickel-iron alloy is more typical of a hexahedrite (H) than of an octahedrite (O), and thus is at variance with the usual medium-octahedrite (Om) classification of Toluca.

The spherical inclusion in the upper left portion of Fig. 1A is 7.5 mm. in diameter. The interior of this inclusion consists, for the most part, of a brownish- to bronze-colored troilite. The periphery is tin-white schreibersite, identified as such and distinguished from cohenite by the boiling, alkaline, sodium-picrate etch-test. The 2 dark, rounded inclusions within the troilite give a qualitative test for chromium, and appear to be a mixture of graphite and daubréelite. The graphite is recognized readily by its soft, black streak, whereas the presence of daubréelite is inferred from the test for chromium and by the fact that a microscopic examination of fragments from these 2 dark areas shows a second black mineral, brittle, harder than the graphite, and non-magnetic.

The right-hand portion of Fig. 1A shows more troilite. This troilite area is separated from the circular area by a vein of 3 minerals: (1) a thin, black band of daubréelite; (2) a wide, black band of graphite; and (3) a white band of schreibersite.

Fig. 1B is similar to Fig. 1A and shows the continuation of the schreibersite-graphite-daubréelite vein. In this view, however, the graphite and daubréelite surround the troilite inclusion.

The appearance of tiny green droplets along the vein and fractures indicates the presence of lawrencite. This observation is confirmed by the presence of chlorine in the chemical analysis (Table 1, §3, *post*).

The rounded and elongate inclusions, as well as the vein material, lead to the speculation that this fragment of the Toluca shower crystallized late. The nickel-iron alloy has undergone a complete transition to the α-phase. The large vein seems to indicate a fracture in the crystallizing iron-nickel phase that was filled with the residual liquid rich in the minor constituents of the molten meteorite. This liquid crystallized to form schreibersite, graphite, and daubréelite and to give the vein appearance. The rounded and elongate inclusions seem to represent liquid globules that crystallized to form troilite, schreibersite, graphite, and daubréelite.

3. *Chemical Analyses.*—A slice of this Toluca meteoritic iron, made parallel to the face shown in Fig. 1B, was analyzed chemically by me; the results are given in Table 1. Isolated portions of the schreibersite

TABLE 1

Chemical Analysis of the Toluca Meteoritic Iron

Iron	72.98%
Nickel	7.98
Cobalt	0.29
Phosphorus	5.54
Sulfur	2.48
Carbon	8.66
Chlorine	0.96
Chromium	0.07
Total	98.96%

vein also were analyzed chemically by me; the results are given in Table 2. From the overall chemical analysis and the schreibersite chem-

TABLE 2

Chemical Analysis of the Schreibersite

	Percent	Ratios	
Iron	69.12%	1.2376	
Nickel	14.67	0.2450	= 2.975
Cobalt	0.19	0.0032	
Phosphorus	15.47	0.4994	= 1.000

ical analysis, calculations of the mineral composition, both by weight and by volume, were made; the results are given in Table 3. The

TABLE 3

Calculated Mineral Composition of the Toluca Meteoritic Iron

	By Volume	By Weight
Kamacite	33.34%	46.20%
Schreibersite	28.67	35.61
Graphite	29.10	8.66
Troilite	6.02	6.58
Lawrencite	1.64	1.72
Daubréelite	0.19	0.19
Total	98.96%	98.96%

mineral composition by volume was made by calculating the molecular proportions of each element in Table 1. All of the phosphorus, plus enough iron, nickel, and cobalt to satisfy the schreibersite analysis, was assigned as schreibersite. All of the chromium, plus enough iron and sulfur to satisfy the theoretical formula of daubréelite, $FeS \cdot Cr_2S_3$, was assigned as daubréelite. The excess sulfur, plus enough iron to make theoretical troilite, FeS, was assigned as troilite. All of the chlorine, plus enough iron to make theoretical lawrencite, $FeCl_2$, was assigned as lawrencite. All of the carbon was assigned as graphite. The remaining iron, nickel, and cobalt were assigned as kamacite. The calculated composition of this kamacite is given in Table 4. A similar calculation gives the mineral composition by weight.

Because of the great irregularity of this meteorite, as shown by the 2 views in Fig. 1, I do not suppose that the given chemical analyses represent the entire fragment. They do, however, give the order of

TABLE 4

Calculated Composition of the Kamacite

Iron	93.61%
Nickel	5.91
Cobalt	0.48
Total	100.00%

magnitude of the concentration of relatively rare meteoritic minerals in abundance.

4. *Acknowledgment.*—I am indebted to Dr. Lincoln LaPaz, Director, Institute of Meteoritics, University of New Mexico, for making available this specimen of the Toluca meteoritic iron for mineralogical investigation.

REFERENCE

[1] Farrington, O. C., "Catalog of the Meteorites of North America," *Mem. Nat. Acad. Sci.*, **13**, 436-54, 1915.

The Spectrum of α Perseid Meteor of 1949*

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ABSTRACT

A Perseid spectrum, obtained in 1949, is compared with 5 other Perseid spectra. Density measures for this spectrum indicate a marked increase in strength, during bursts, of the H and K lines of CaII relative to the strong neutral Fe and Mg line at 3830 A. The available data indicate tentatively that: (1) Perseid spectra resemble one another more than do type-*Y* spectra as a whole; (2) the meteorites producing Perseid meteors are less diverse in composition than are aerolites in general.

The spectrum shown in Fig. 1 was produced by a Perseid meteor in the course of the interval from $1^h\,12^m\,30^s$ to $1^h\,34^m\,00^s$ P.S.T., 1949 August 13. From the point of observation ($\lambda = +120°\,40'$, $\phi = +39°\,47'$), it appeared about midway between Capella (α Aurigae) and γ Persei. Altho this region of the sky was kept under general surveillance during the exposure, this meteor escaped visual observation.

The spectrum was photographed on Eastman Super XX film with an $f/5.6$ lens of 130 mm. focal length, in front of which a 30° flint prism was mounted. The average dispersion between Hγ and Hδ with this instrument is 468 A./mm.

Wavelengths and comparator readings for calculating 2 sets of Hartmann constants were obtained from the spectrum of α Persei. As the H and K lines of CaII were easily recognized in the spectrum of the

*Read at the 13th Meeting of the Society, Flagstaff and Barringer Meteorite Crater, Arizona, 1950 September 5-7.

FIG. 1

THE SPECTRUM OF A PERSEID METEOR OF 1949

(The direction of motion was from the upper left to the lower right.)

meteor, comparator readings for the 23 lines in that spectrum, at the time of the second burst, could be readily converted to the zero-point of the comparator readings for α Persei. The application of the 2 Hartmann formulas to these 23 adjusted comparator readings resulted in the wavelengths shown in the first column of Table 1. Column (2) con-

TABLE 1

WAVELENGTHS AND IDENTITIES OF THE LINES IN THE SPECTRUM OF THE METEOR

Observed Wavelength	Relative Intensity	Multiplets Involved	Computed Wavelength	O — C in Angstroms (A.)
3734.8 A.	2	Fe I(5) Fe I(21)	3735.4 A.	—0.6
3746.6	2	Fe I(5) Fe I(21)	3747.6	—1.0
3757.0	2	Fe I(21)	3762.0	—5.0
3783.6	1	Fe I(21) Fe I(22) Ni I(30)? Ni I(33)?	3783.9	—0.3
3794.8	1	Fe I(21) Fe I(22)	3797.2	—2.4
3813.6	1	Fe I(22) Ni I(33)?	3810.5	+3.1
3824.8	3	Fe I(4) Fe I(20) Fe I(45)	3821.7	+3.1
3837.5	5	Fe I(20) Fe I(45) Mg I(3)	3836.0	+1.5
3859.7	3	Fe I(4) Fe I(20) Fe I(22) Ni I(32)?	3861.2	—1.5
3880.2	2	Fe I(4) Fe I(20) Fe I(22)	3878.6	+1.6
3892.3	1	Fe I(4) Fe I(20) Fe I(45)	3892.2	+0.1
3907.0	1	Fe I(4) Fe I(20) Fe I(45) Si I(3)	3906.2	+0.8
3933.8	10	Fe I(4) Fe I(20) Ca II(1)	3932.4	+1.4
3953.7	1	Al I(1)	3953.0	+0.7
3968.6	9	Fe I(43) Fe I(45) Ca II(1)	3968.0	+0.6
4050.3	2	Fe I(43)	4050.8	—0.5
4128.9	2	Fe I(3) Fe I(43) Si II(3)	4136.5	—7.6
4220.0	2	Fe I(3) Ca I(2)	4226.4	—6.4
4471.6	1	Fe I(2) Mg II(4)	4465.1	+6.5
5166.1	2	Fe I(1) Fe I(36) Fe I(37) Mg I(2)	5172.7	—6.6
5683.5	2	Si I(10) Si I(11)	5688.6	—5.1
5889.4	3	Na I(1)	5892.8	—3.4
6135.5	2	Ca I(3)	6135.6	—4.1

tains a rough visual estimate of the relative line-intensities on a scale of 10. The third column gives the tentative identification of the multi-

plets involved in the production of the spectral lines. The numbers in parentheses are the multiplet reference-numbers from Dr. Charlotte E. Moore's "A Multiplet Table of Astrophysical Interest, Revised Edition."[1] The fourth column lists computed wavelengths obtained by averaging the wavelengths of the multiplet components making up each line, weighted according to their intensities in Dr. Moore's table. The residuals, observed minus computed, appear in the last column. If the variation in dispersion along the spectrum is neglected and if the computed wavelengths are assumed to be correct, the probable error of an individual observed wavelength is ± 2.3 A.

The residuals at the extremities of the spectrum are preponderantly negative. This fact may be due to slight scale differences between the spectrum of the meteor and that of α Persei and to the uncertainty in the Hartmann formula used for determining the long wavelengths. Altho 5 A. seems to be a sizable residual, at 5000 A. it represents only ½ of the smallest division on the drum of the comparator, or 0.005 mm. on the film!

Where multiplets of nickel appear in the identification, they are followed by a question mark. It is impossible in this spectrum to establish the presence or absence of nickel, because of blending. The average residual for those lines in which nickel was assumed to be present was reduced from 2.1 A. to 1.6 A. by including the nickel. In terms of the probable error, this difference is insignificant. It would be interesting, if possible, to confirm the presence or absence of nickel, as this would have a bearing on the similarity or dissimilarity of the meteorites producing shower meteors and the meteorites that reach the Earth. Nickel has been identified in a sporadic meteor with a spectrum of type *Z*.[2] To the best of my knowledge, it has not been well identified in any type-*Y* spectra.

The predominance of iron multiplets 1, 2, and 3 in the lines in which they appear is uncertain. If the line 4471.6 A. were attributed solely to MgII, its residual would be —9.6 A. This procedure would make the residual larger but more consistent with adjacent residuals. The inclusion of SiII in 4128.9 A. reduces the residual by 2.2 A. The possible blending of multiplets of ionized atoms with neutral-iron multiplets arising from the lowest energy-level complicates the judging of these lines as lines of high or low excitation-potential. This uncertainty occurs in the very lines otherwise most suited for effective-temperature determinations of the iron vapor in the meteor.[3] In view of these uncertainties in identification, and in view of the fact that these lines were too faint to observe between bursts, no study of the effective temperature of the iron vapor or of its variation during and between bursts was attempted.

Density measures were made, however, on the K line of CaII and on the neutral iron-magnesium blend at 3830 A. The visual densitometer that was used for this purpose and the method by which it was em-

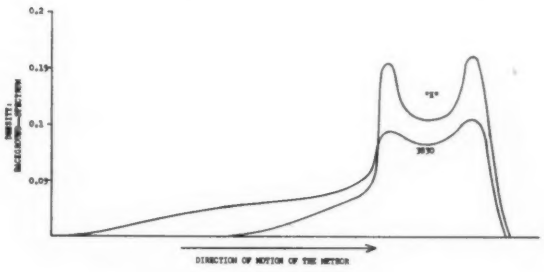

FIG. 2

PHOTOGRAPHIC DENSITY-VARIATION ALONG THE PATH OF THE METEOR

ployed have been previously described.[4] The results of these measures are shown in Fig. 2. The abscissas are arbitrary linear units along the path of the meteor, and the ordinates are the differences between the photographic density of the film background and that of the spectrum. The increased strength during bursts of the K line of CaII, relative to the 3830 A. line of FeI and MgI, is clearly shown. This increase in excitation during bursts is very similar to that observed in an earlier Perseid spectrum.[5] Moreover, the spectrum exhibits the same marked increase in excitation along its path, exhibiting first a phase in which only neutral lines are present. In the second phase, which is short in this spectrum, the H and K lines of CaII are present, but they are less intense than the neutral line at 3830 A. In the final bursts, the CaII lines are the predominant feature of the spectrum.

Millman[6] has noted that the spectra of meteors from a given shower are remarkably similar. This conclusion should be particularly true if the spectra are obtained with the same instrument. Table 2 provides a basis for comparison of 6 Perseid spectra. The approximate wavelengths shown at the left indirectly include all of the lines identified in the 6 spectra. The column numbered (1) pertains to a Perseid spectrum obtained in 1948,[7] column (2) to the spectrum discussed in this paper, and the last 4 columns to spectra described by Millman.[8,9] If a line is individually identified in a spectrum, its presence is recorded by an *X*. If the line falls within the limits of a band, a virgule (/) is used. If the line appears to be resolved into 2 components, this fact is indicated by an *XX*.

Altho meteors (1) and (2) differed in brightness by at least 1-2 magnitudes, their spectral similarities are notable. Outstanding differences exist for only very faint lines at the extremities of the spectra, where the emulsion sensitivity is low. Millman's preliminary note[10] for spectrum (6) included only the brightest lines. Except for the iron blend at 4375 A., all lines shorter than 6000 A. listed for this spectrum and within the emulsion sensitivity-range of the other spectra are present in the other spectra.

TABLE 2

A SPECTRAL COMPARISON OF 6 PERSEID METEORS

Approximate Wavelength	(1)	(2)	(3)	(4)	(5)	(6)
3722 A.	X		X	/		
3736	X	X	X	/		
3747	X	X	X	/		
3761	X	X	X	/		
3784		X				
3797	X	X	X			
3814	/	X		/	/	
3825	/	X		/	/	
3836	X	X	X	/	XX	X
3858	X	X	X	/	XX	X
3879	/	X	X	X	X	
3889	/	X			X	
3908	X	X	X	X	X	
3924					XX	
3934	X	X	X	X	X	X
3954		X		/	XX	
3968	X	X	X	X	X	X
4006			X	X	XX	
4057	X	X	X	X	X	
4133	X	X		X	X	X
4185				X	X	
4225	X	X		X	X	X
4285	X					
4375	X					X
4475	X	X		X	X	X
5170	X	X				X
5685		X				
5890	X	X				X
6130		X				
6185	X					
6340						X
6440						X

The lines in column (6), however, are common also to many other non-Perseid spectra of type *Y*. An examination of data for 14 such spectra published by Millman[11] indicates that the lines of column (6) appear, when expected, in 76% of the cases. The corresponding figure for the Perseids of Table 2 is 94%. The most significant single factor contributing to this greater similarity is the more consistent appearance of magnesium lines in the Perseid spectra. Watson[12] states that calcium is sometimes completely absent from meteorites. The appearance of strong CaII lines in all 6 spectra and of MgI lines in at least 5 tentatively indicates that the meteorites producing the Perseids are less diverse in composition than are aerolites as a whole.

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[1] *Princeton Obs. Contr.* No. 20, 1945.

[2] Millman, Peter M., "An Analysis of Meteor Spectra: Second Paper," *Harvard Coll. Obs. Ann.*, **82**, No. 7, 149-77, 1935.

[3] Such determinations appear in the following references:

(*a.*) Millman, Peter M., "An Analysis of Meteor Spectra," *Harvard Coll. Obs. Ann.*, **82**, No. 6, 113-46, 1932.

(*b.*) Millman, *loc. cit.*, ref. ([2]), *ante*.

(*c.*) Russell, John A., *C.M.S.*, **4**, 250-4; *P. A.*, **58**, 134-8, 1950.

[4] Russell, *loc. cit.*, ref. ([3]*c*), *ante*.

[5] Russell, *loc. cit.*, ref. ([3]*c*), *ante*.
[6] Millman, Peter M., "One Hundred Meteor Spectra," *Astron. Jour.*, **54**, 177-8, 1949.
[7] Russell, John A., *C.M.S.*, **4**, 191-6 and 204-5; *P. A.*, **57**, 187-92 and 344-5, 1949.
[8] Millman, *loc. cit.*, ref. ([3]*a*), *ante*, spectra III, IV, and VI.
[9] Millman, Peter M., *Jour. Roy. Astron. Soc. Canada*, **34**, 117-29, 1940.
[10] Millman, *loc. cit.*, ref. ([9]), *ante*.
[11] Millman, *loc. cit.*, refs. ([2]) and ([3]*a*), *ante*.
[12] Watson, Fletcher G., *Between the Planets*, pp. 108-9, The Blakiston Co., Philadelphia, 1941.

The Weights of the Two Largest-Known Meteorites

According to J. D. Figgins (the author of Ch. 21, "The Cape York Meteorites," pp. 133-40, in H. H. Nininger's *Our Stone-Pelted Planet*, 1933), the weight of "Ahnighito," the largest of the 4 recovered Cape York, Melville Bay, Greenland, siderites (ECN = + 650,760:; subcl. = Om (medium octahedrite)), is about 66 tons of 2,000 lb., and, according to C. C. Wylie (*Sky & Tel.*, **10**, 3-4, 1950), 65. The overall dimensions of this meteorite, which has been on exhibition for many years in the American Museum of Natural History and the Hayden Planetarium in New York City, are $11\frac{1}{2} \times 7\frac{1}{2} \times 6$ ft.

According to L. J. Spencer (*Min. Mag.*, **23**, 1-18, 1 pl., 1932), the present weight of the Hoba West, near Grootfontein, Southwest Africa, siderite (ECN = — 179,196; cl. = D1 (primary or nickel-rich ataxite)), which has hitherto been generally regarded as being by far the largest-known meteorite of the world, is 66 "ordinary" tons, and, according to C. C. Wylie (*loc. cit., ante*), $67\frac{1}{2}$. The maximum dimensions of this meteorite, which still lies *in situ*, are $10 \times 9 \times 3$ ft.

Thus it appears likely that the present weights of the 2 largest-known individual meteorites—Hoba West and "Ahnighito"—are just about the same and are between 65 and 70 "short" tons—as we have for some time suspected.—F.C.L.

Meteoritics: A Short Editorial

Meteoritics, which is epistemologically a branch of astronomy—itself the science of the Universe or Cosmos—is defined as the science of meteorites and meteors. A meteorite is a solid body of subplanetary mass that either is in space or has come therefrom and is falling or has fallen as a discrete unit onto the Earth or onto some other astronomical body where, if it has landed, it still retains its essential cosmic character; and a meteor is the luminosity—*i.e.*, the luminous thing—that results when a meteorite from space penetrates the atmosphere of the Earth or that of some other astronomical body and becomes usually a falling meteorite.

In view of the foregoing definitions, meteoritics is, for most practical purposes, that branch of astronomy that is concerned with the investigation of the *actual matter* that reaches us from space, whereas every

other branch of the science is involved, either directly or indirectly, with the study of the *radiant energy* that comes to us from extraterrestrial realms. Since the general consensus of contemporary astronomers—not just meteoriticists—is that at least 50 per cent of the mass of the Universe exists in meteoritic form, the importance of the pursuit of meteoritics to every endeavor to evaluate the economy of Nature is so apparent as to call for no defense.—F.C.L.

President of the Society: L. F. Brady, 922½ Forest Avenue, Tempe, Arizona
Secretary of the Society: John A. Russell, Department of Astronomy, University of Southern California, Los Angeles 7, California

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The International Astronomical Union has recently published Vol. VII of its Transactions which covers what was done at the Zurich meeting, held in August, 1948. This volume is available to most professional astronomers and in the libraries of many observatories, but is probably not in reach of most amateurs. Hence, a brief résumé of the report of the Commission No. 22, which deals with meteoric astronomy, may be of interest to our members.

The membership of this, as of all the other commissions, is drawn from many countries, and endeavors to have persons upon it who represent every phase of the work. A few others are sometimes included for practical reasons. The president of Commission No. 22 now is Professor F. L. Whipple of Harvard College Observatory, one of the leading men in meteoric research. It may be of some interest to A.M.S. members to say that the writer held this presidency for three terms, namely from 1925 to 1935. The present members of the Commission are as follows: Astapovich, Bečvář, Bosler, Chant, M. Davidson, Dobson, N. Donitch, Dufay, Elvey, J. W. Evans, Fedynsky, Fesenkov, Madame Flammarion, Gatterer, Guth, Harang, Housman, Kaplan, Kopal, LaPaz, Leonard, Link, McIntosh, Millman, Nielson, Nininger, Olivier, Opik, Porter, Prentice, V. M. Slipher, Stormer, Vandekerkhove, and Watson. Of these, five are or have been members of the A.M.S. International complications officially keep out the Germans, though many cooperate, hence we do not find Cuno Hoffmeister a member, one of the very best men in meteoric astronomy. The names of most of the above are well known from their numerous and valuable publications on meteors; a very few, I confess, I do not recognize as ever having done any appreciable work on the subject.

The actual report covers ten years, from 1938 to 1948. Also the interval saw revolutionary methods applied to meteors as well as most important work along conventional lines. Outstanding among the former was the application of radar and other electronic techniques. Using this, meteors can be detected in the daytime, and methods have been devised to determine heights and velocities at night. Radiants at all hours have been detected. A study of meteor trails found on the great collection of plates at the Harvard Observatory has led to an intensive photographic campaign there, and at its sub-stations. This is being extended rapidly by the devising of a new type of super-Schmidt camera, with which rela-

tively faint meteors can be photographed. Extensive theoretical investigations have been made of the upper atmosphere, based upon studies of meteors. New methods of deducing heights and velocities were derived. Studies on rates, magnitudes, and long-enduring trains were made. Much work was done on the discovery, analysis, and physical structure of meteorites, and attempts to determine their age by the helium and other methods. Millman has continued his most important work on meteor spectra, giving us definite information on the composition of meteors. As will be noted, there are a number of Russians among the members, and a great amount of valuable work on meteors is being done in the U.S.S.R. (The writer notes with regret that the Soviet authorities, with their peculiar mentality, have forbidden Russian scientists to publish in other languages, even stopping the résumés in either English, French or German which, up to a couple of years ago, usually were printed at the end of the article itself. As few Americans read Russian, this act has made much of their work relatively useless to the rest of us.) The report, as a whole, shows that meteoric astronomy made great advances in the 10-year period covered.

Each commission passes a number of resolutions which are then submitted to the Executive Committee and adopted or not by them, those adopted having the prestige of the whole I.A.U. behind them.

The following three were thus adopted as to meteors:

(1) The Commission recommends that the observations of meteors made simultaneously by the electronic (radar) and visual or photographic methods be extended, because this commission is convinced that the continuation and extension of electronic (radar) observations are actually essential for the progress of astronomy relative to meteors and the researches which are related.

(2) The Commission recommends that stellar charts designed for the visual observation of meteors be prepared, and that a sub-commission be constituted to study the form of these charts and the style of their publication. This commission will have as chairman M. Millman and will include MM. Bečvář, Olivier, and Prentice.

(3) That astronomers call the attention of physicists to the application of new methods of research to the study of meteorites made in the laboratories; such research should include in a systematic fashion all representative classes of meteorites.

Another meeting of the I.A.U. is due next summer and the invitation of the Academy of Sciences of the U.S.S.R. has been accepted to hold it in Leningrad. Anyone who has a good idea for advancing meteoric astronomy should communicate the same to some American member of No. 22, and, if it seems of value to him, he will doubtless pass it on to Dr. Whipple for more general consideration.

Turning now to our local affairs, disappointingly few members have so far reported that they observed the Orionids. As few Leonids were expected, lack of observers made less difference. The record for 1950 will easily be held by C. E. Worley of Ottumwa, Iowa, who up to November 5 had reported 2300 fully plotted and recorded meteors. Professor Khan reports that meteors were markedly fewer than usual at his station, Begumpet, Deccan, India, than in recent years. He was only able to report 250 observed up to mid-September, and states very positively that poor visibility was not the main reason but actual lack of meteors.

Several fine fireballs have been reported during the fall, but our observers have, in some cases, been slow in sending in the information they gathered. There was a very bright one over New England at 7:30 P.M., E.S.T., on November 2.

Reports are still reaching us and it is hoped a solution can be made. R. M. Dole of Cape Elizabeth, Maine, saw a —8 Leonid at 14:45, E.S.T., on November 16/17, passing behind broken clouds. He estimates that part of the train was visible for 45 minutes. Further information on this is greatly desired. On November 15/16 at 6:05 P.M., E.S.T., there was a large fireball over Pennsylvania. Others on which further reports are much desired are: on Oct. 30 at 6:01 P.M., E.S.T., over Ohio; on Oct. 20 at 6:50 P.M., E.S.T., from New Jersey and eastern Pennsylvania to the west; on Sept. 19/20 at 13:40, C.S.T., from Missouri; and on Oct. 4 at 5:20 P.M., C.S.T., another fine one was seen from St. Louis, Mo., to the east. We have single reports on many others; but all those mentioned were bright enough to be widely noted. We earnestly request that any reader, who can, should supply us with further data on these fireballs.

In passing, it may be remarked that I would welcome any experienced member of the A.M.S. volunteering to personally follow up and compute the heights of a fireball in his section of the country, as is done so ably by Professor J. H. Pruett of Oregon. As such work is somewhat bewildering for the first few times, I would gladly give advice and assistance by mail, as has frequently been done. We badly need other contributions to Meteor Notes, and I assure our members that I would incorporate, with much pleasure, papers of the proper type, written by others.

May I remind all that the recent publication of the paper on telescopic meteors, and formerly of the two on long-enduring trains, does not mean that I am not eagerly collecting data on both subjects for a future publication on each. Blanks and instructions for telescopic meteors will be furnished any observer who uses a telescope, on request.

In closing may I request our members to send in their dues in January without forcing us to take the time, expense, and trouble of reminding them? And may I express the fervent hope that 1951 will prove one of the best in our history as to amount and value of meteoric work reported by our members.

Flower Observatory, Upper Darby, Pennsylvania, 1950 December 13.

Planetary Phenomena in 1951

By PAUL S. WATSON

GRAPHIC TIME TABLE OF THE HEAVENS*

This is a condensed and simple almanac in graphic form published annually by the Maryland Academy of Sciences, Baltimore. It gives the rising and setting times of the Sun, Moon, and brighter planets, the beginning of morning twilight and the ending of evening twilight, the times when the visible planets and certain other objects of particular interest cross the meridian, occultations of bright objects by the Moon, and other useful astronomical information.

It is computed for 40° north latitude and 90° west longitude (6 hours west of Greenwich), and is therefore correct for only this point on the Earth, but it can be used to advantage anywhere in the United States, provided the user, wherever he is, make correction for the distance he may be from his own particular time meridian. The corrections for a number of important cities are listed below:

*See insert between pages 40 and 41.

Atlanta	+38 min.	Memphis	0 min.
Baltimore	+ 6 min.	Milwaukee	— 8 min.
Birmingham	—13 min.	Minneapolis	+13 min.
Boston	—16 min.	New Orleans	0 min.
Buffalo	+15 min.	New York	— 4 min.
Chicago	—10 min.	Oklahoma City	+32 min.
Cincinnati	+38 min.	Philadelphia	+ 1 min.
Cleveland	+27 min.	Pittsburgh	+20 min.
Denver	0 min.	Rochester	+10 min.
Detroit	+32 min.	Salt Lake City	+28 min.
Helena	+28 min.	San Francisco	+10 min.
Houston	+22 min.	Santa Fe	+ 4 min.
Indianapolis	—16 min.	Seattle	+10 min.
Kansas City	+18 min.	St. Louis	+ 1 min.
Los Angeles	— 7 min.	Washington	+ 8 min.

(Note: Places for which the correction is minus are east of the standard time meridian, and therefore all events, with the exception of eclipses and occultations, will be earlier by the amount stated. All places with plus correction are west and therefore these events occur later.

For most events, such as the rising and setting of the planets, it makes practically no difference what standard time meridian in the United States is used. For moonrise and moonset, however, the times shown are correct for the 90th meridian. For the 75th, 2 minutes should be subtracted, while for the 105th and 120th, 2 and 4 minutes, respectively, should be added on the average. Certain events, such as eclipses of the Moon and the phenomena of Jupiter's satellites, occur at a specified time regardless of location. In these cases the time is given in Eastern Standard Time and the appropriate correction should be applied for other time belts. For occultations the time given is for Washington, D. C. For other locations consult the *American Ephemeris and Nautical Almanac*.

Correction for difference in latitude is comparatively minor and may in general be neglected.

Separate copies of the Time Table, as here reproduced, may be obtained from the Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral Street, Baltimore 1, Maryland, at 10c each. Substantial discount on quantity orders. Blueprints of the original drawing before reproduction, 40 by 27 inches, may be obtained at $1 each. A Quebec Edition in French, computed for 47° north latitude, is also available.)

Instructions for the use of the Time Table

Across the top of the Time Table are shown the hours of the night from 4 P.M. to 8 A.M. the next morning. Down the sides are indicated the dates, each horizontal line representing a Thursday evening. The dashes on the sunset and sunrise curves aid interpolation on intermediate days. The various lines indicate the rising, setting, and transit times of the heavenly bodies.

The phases of the Moon are indicated by the conventional symbols. Thus, the Moon is new within 12 hours of 8 P.M., C.S.T., on January 7 and sets at 4:36 P.M. (even though invisible). First quarter is shown on the night of January 14-15, when the Moon will set at 12:48 A.M. Full Moon takes place on January 22, when it will rise at 4:37 P.M., and last quarter will occur on the night of January 30-31, when the Moon will rise at 1:42 A.M. The small black circles show moonset for the first half of the lunar month, and the small open circles indicate moonrise for the second half of the lunar month. Obviously, the various phases cannot be indicated closer than 12 hours.

Small squares on planet curves indicate quadrature and half circles greatest elongation. The "rose" on the rising and setting curves of Venus indicates when that planet is at greatest brilliancy. Opposition of a planet is shown by the con-

ventional symbol. Roman numerals give Sidereal Time at midnight. The curve along the midnight line indicates the Equation of Time (this is the difference between mean or clock time and apparent or Sun Time). When the curve is left of the midnight line the Sun is fast and arrives at the meridian before 12 o'clock noon, Local Time, by the amount indicated. When the curve is right the Sun is slow. The small numbers on the left hand side of the Time Table indicate the Julian Day number, of interest to variable-star observers. Thus, the Julian Day, beginning Greenwich Noon, January 1 is 2,433,648. The diagonal lines beginning at the midnight line, marked Pleiades, Great Nebula in Orion, Castor, etc., indicate when these objects are on the meridian, that imaginary line running north and south which divides the sky into its eastern and western halves. Other information on the Time Table is self-explanatory.

Now, the events of the night of January 4-5 can be easily found by following the horizontal line for that date across the page from left to right: The Julian Day number is 2,433,651; Mercury sets at 4:17 P.M.; the Sun sets at 4:48 P.M.; Venus sets at 5:43; evening twilight ends at 6:24; Mars sets at 7:22; the Pleiades transit or cross the meridian at 8:49; Jupiter sets at 9:03; the Great Nebula of Orion transits at 10:36; Saturn rises at 11:05; the curve for the Equation of Time indicates that the Sun is slow and will not arrive at the meridian until 5 minutes after 12 o'clock noon, Local Time; Saturn transits at 5:14 A.M.; the Moon rises at 5:20; morning twilight begins at 5:45; Mercury rises at 6:40 and the Sun rises at 7:22 A.M.

The Planets for 1951

Based on the Graphic Time Table of the Heavens, a summary of the interesting planetary events for the year 1951 is given below. For more detailed information reference should be made to the *American Ephemeris and Nautical Almanac*, the principal source used in the calculation of the Time Table.

Mercury. This sprightly and fast moving planet will make three appearances as an evening star and three as a morning star during 1951. Of the evening elongations that of April 5 is by far the best, the planet setting $1^h 38^m$ after the Sun. The other eastern or evening elongations will be on August 3 and November 27. To find the planet one should look somewhat south of the place where the Sun has set, from a few days before until several days after the above dates, and in the twilight glow, should the evening be clear, the planet will be seen shining as a star of the 1st magnitude.

The western or morning elongations will be on January 24, May 23, and September 17. The January and September elongations will be more favorable than the one in May. At the end of the year Mercury is again moving westward from the Sun and appearing as a morning star, but greatest elongation does not occur until 1952. To see Mercury as a morning star, one should look south of the approximate place where the Sun will rise.

Venus. The year 1950 was rather a poor one for Venus, but in the spring and early summer of 1951 this planet will be well seen in the evening sky. Greatest elongation will occur on June 25, when the planet will be 45° 25′ east of the Sun, setting $2^h 43^m$ after sunset. Greatest brilliancy will be on July 28 and its stellar magnitude then will be —4.2. After conjunction with the Sun on September 3, Venus will move swiftly to the western side of the Sun and will reach greatest elongation as a morning star on October 11, when its magnitude will be —4.3, and greatest elongation on November 13, when it will be 46° 39′ west of the Sun.

and will rise at 2:45 A.M., $3^h\,56^m$ before the Sun. Venus will remain a morning star for the rest of the year.

Mars. This year will be an unfavorable one for observing Mars. From the first of January until the middle of May this planet will be an evening star visible low in the western sky after sunset but it will be of the second magnitude and so will not be conspicuous. After conjunction with the Sun on May 22, Mars will be a morning object, and by the end of the year will rise at 1 A.M. Its brightness by then will have increased to nearly the first magnitude. The next opposition will occur in May, 1952.

Jupiter. The elongations of the inferior planets, Mercury and Venus, differ from year to year. Some years Mars is with us but during others is absent from our sky; the tilt of Saturn's rings changes, altering the appearance of the planet greatly; but the giant planet, Jupiter, year after year, appears very nearly the same. Every thirteen months it is at opposition brightening the evening sky with its yellow glow. From the beginning of 1951 until March 11 Jupiter will be an evening star though too near the Sun to be really well seen. During this time it will be in the constellation of Aquarius. Some weeks after conjunction with the Sun on March 11, Jupiter will reappear low in the morning twilight. By the 1st of July the planet will rise at midnight. Opposition will take place on October 2, the planet remaining in the evening sky for the rest of the year. At the end of the year it will set a few minutes before midnight. At the time of opposition Jupiter will be in the constellation of Pisces, several degrees south and west of the star Delta Piscium.

An interesting conjunction of Mars and Jupiter will occur on the evening of February 7. At their closest approach, which happens during daylight—at 1 P.M., C.S.T., the planets will be only 10′ of arc apart.

Jupiter will be particularly interesting to watch with small telescopes on those evenings marked by circles on the "Jupiter Transit" curve. These indicate the nights on which occultations or eclipses of one or more of Jupiter's four bright moons may be seen between the hours of 6 and 10 P.M., C.S.T.

Saturn. Saturn will be an evening star from the first of the year until the end of September. Opposition will take place on March 19. The planet will then be located in Virgo a few degrees east of Beta Virginis. From the end of September until the end of the year the planet will be a morning object. At the end of the year it will rise at 1 A.M.

During 1950 the Earth passed through the plane of Saturn's rings. At the beginning of 1951 the Earth will be 4° above the plane. This will diminish to only 1° above at the end of May, but will increase again after this so that at the end of the year the Earth will be 9° above.

Two interesting conjunctions of Saturn with other planets will occur during 1951. In the early morning sky on November 21 Saturn and Venus will be in conjunction. Venus will be slightly more than ½° south of Saturn. Then in the morning sky on December 19, Saturn will be in conjunction with Mars. Mars will be 40′ south of Saturn.

Uranus. The planets Uranus, Neptune, and Pluto are not included on the Time Table because Neptune and Pluto are totally invisible to the unaided eye and Uranus can be glimpsed only under extremely favorable conditions. There will be no opposition of Uranus during 1951. The last opposition was on December 29, 1950, and the next will be on January 3, 1952. Since the synodic period of Uranus (from opposition to opposition) is 369.19 days it can be seen that a

year without an opposition is a rare occurrence. A rough calculation shows that the average frequency of such an event is about once every 91 years. So the last year in which there was no opposition of Uranus was about 1860, and the next will be within a year or so of 2042. On January 1 the position of Uranus will be R.A. $6^h\,32^m$, declination 23° 34′ north. This is roughly 3° east and 1° north of the naked-eye star Mu Geminorium. Its magnitude will be 5.8 so it should just about be visible to a good eye on a clear moonless night.

Neptune. Neptune will be at opposition on April 8 at R.A. $13^h\,9^m$, declination 5½° south, which is about 1° north of the star Theta Virginis. This is a rather starless region and since the magnitude of Neptune at this time is about 7.7 it should not be difficult to locate with a small telescope.

Pluto. The most distant planet Pluto will be at opposition on February 7 at R.A. $9^h\,36^m$, declination 23° 32′ north. This is about 2° southeast of the star Upsilon 2 Cancri, but the planet is visible only with large instruments.

Eclipses

In the year 1951 there will be two eclipses, both will be annular eclipses of the Sun and both will be visible from parts of the United States.

This is the smallest number of eclipses which can occur in any one calendar year. The greatest number possible is seven, five solar and two lunar, or four solar and three lunar. On the average the most usual number is about four. The last year in which seven eclipses occurred was in 1935, but this will not happen again until 1982. In that year there will be four solar and three lunar eclipses. The next time five solar and two lunar eclipses will take place will not be until the year 2160.

I. An annular eclipse of the Sun, March 7, 1951, the annular path beginning at sunrise somewhat west of New Zealand. Moving eastward, the path crosses the South Pacific, Central America, and ends at sunset in the Atlantic Ocean a few degrees north of the coast of Venezuela. The partial phases will be visible from a considerable part of the United States, Central and most of South America, except Argentina and Chile, and eastern Brazil.

The circumstances of the eclipse, in Central Standard Time, the day beginning at midnight, are as follows:

		d	h	m	Longitude ° ′	Latitude ° ′
Eclipse begins	March	7	12	4.0	—177 40	—37 30
Central Eclipse begins		7	13	6.2	—161 18	—42 32
Central eclipse at local apparent noon		7	14	38.6	+126 52	—21 28
Central eclipse ends		7	16	40.2	+ 68 40	+14 35
Eclipse ends		7	17	42.6	+ 84 45	+19 38

The local circumstances of this eclipse from St. Louis, Mo., and Washington, D. C., are given below:

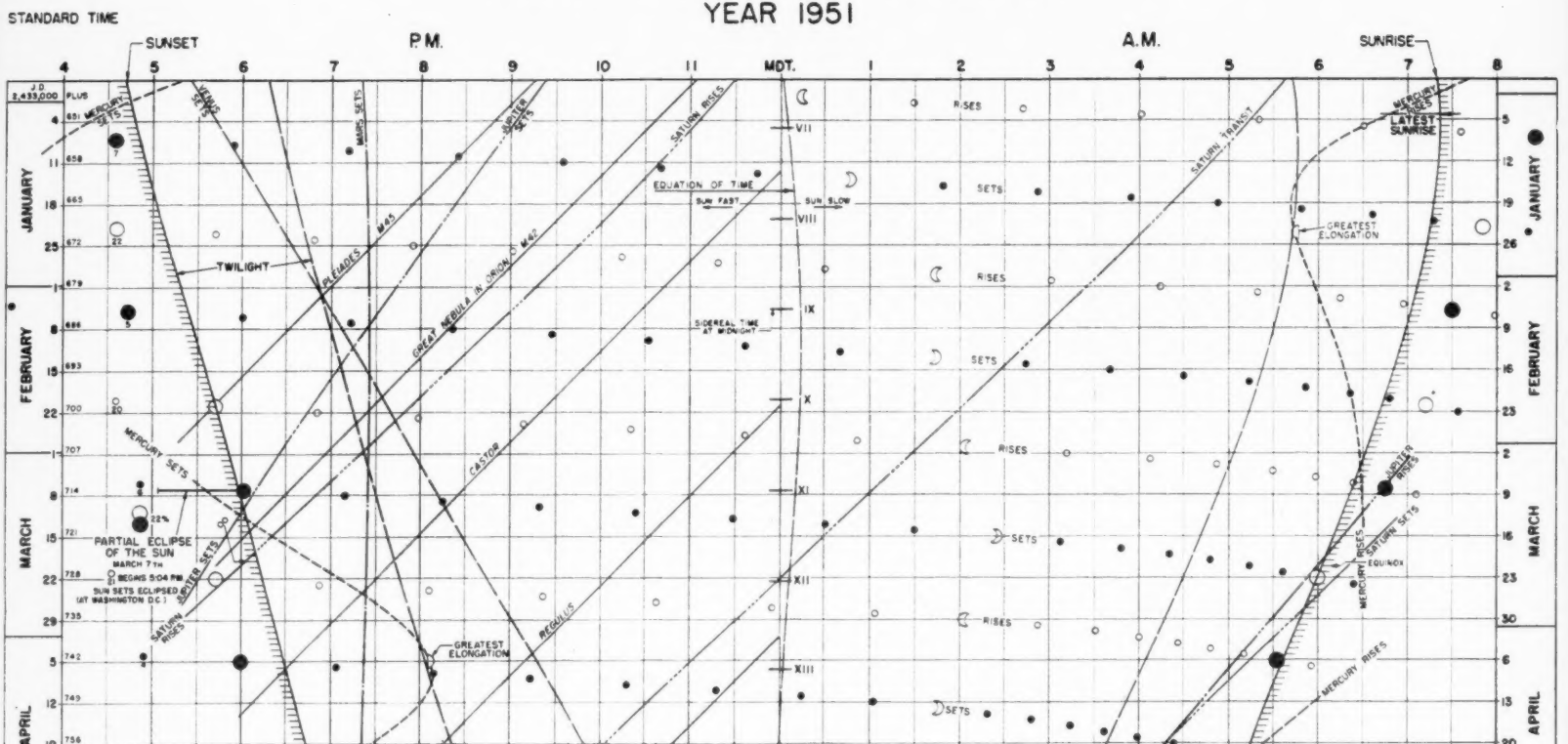
	St. Louis h m	Washington h m
Eclipse Begins	16 6 C.S.T.	17 4 E.S.T.
Middle of Eclipse	16 43	17 44
Eclipse Ends	17 18	...
Magnitude at mid-eclipse	0.16	0.22

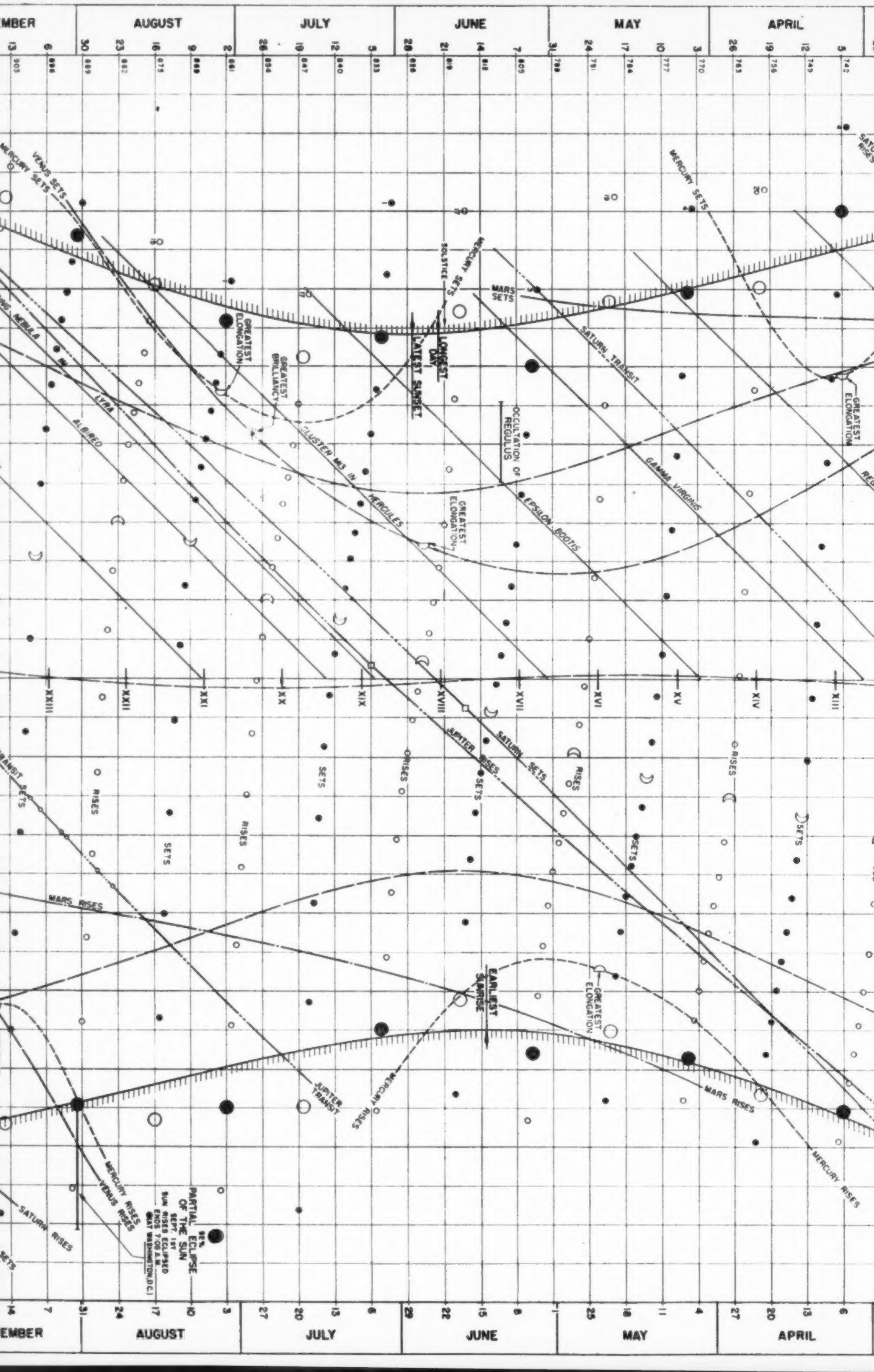
At Washington, D. C., the sun sets eclipsed, the end of the eclipse being below the horizon. For the times at other locations consult the *American Ephemeris and Nautical Almanac.*

THE MARYLAND ACADEMY OF SCIENCES

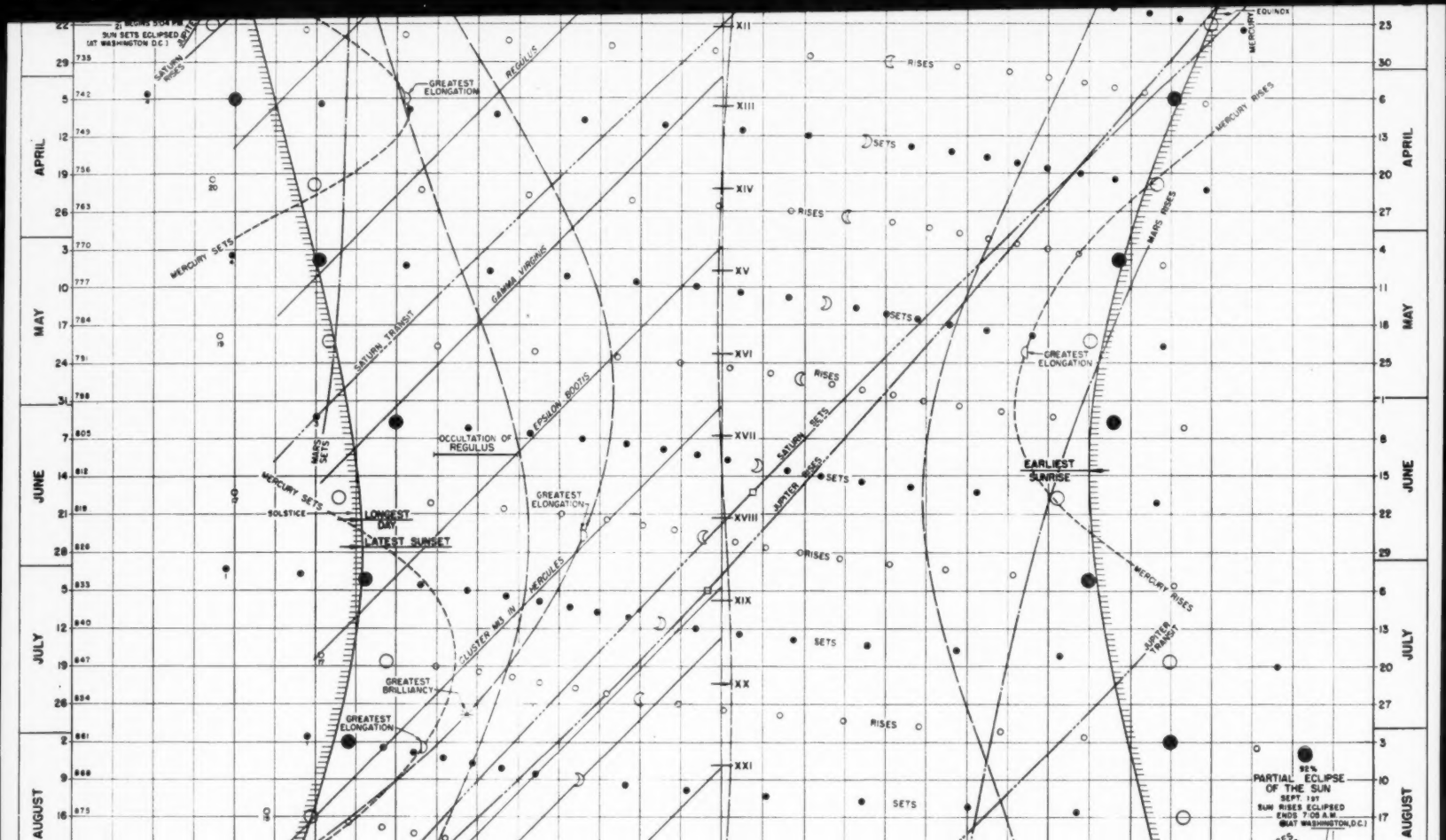
GRAPHIC TIME TABLE OF THE HEAVENS

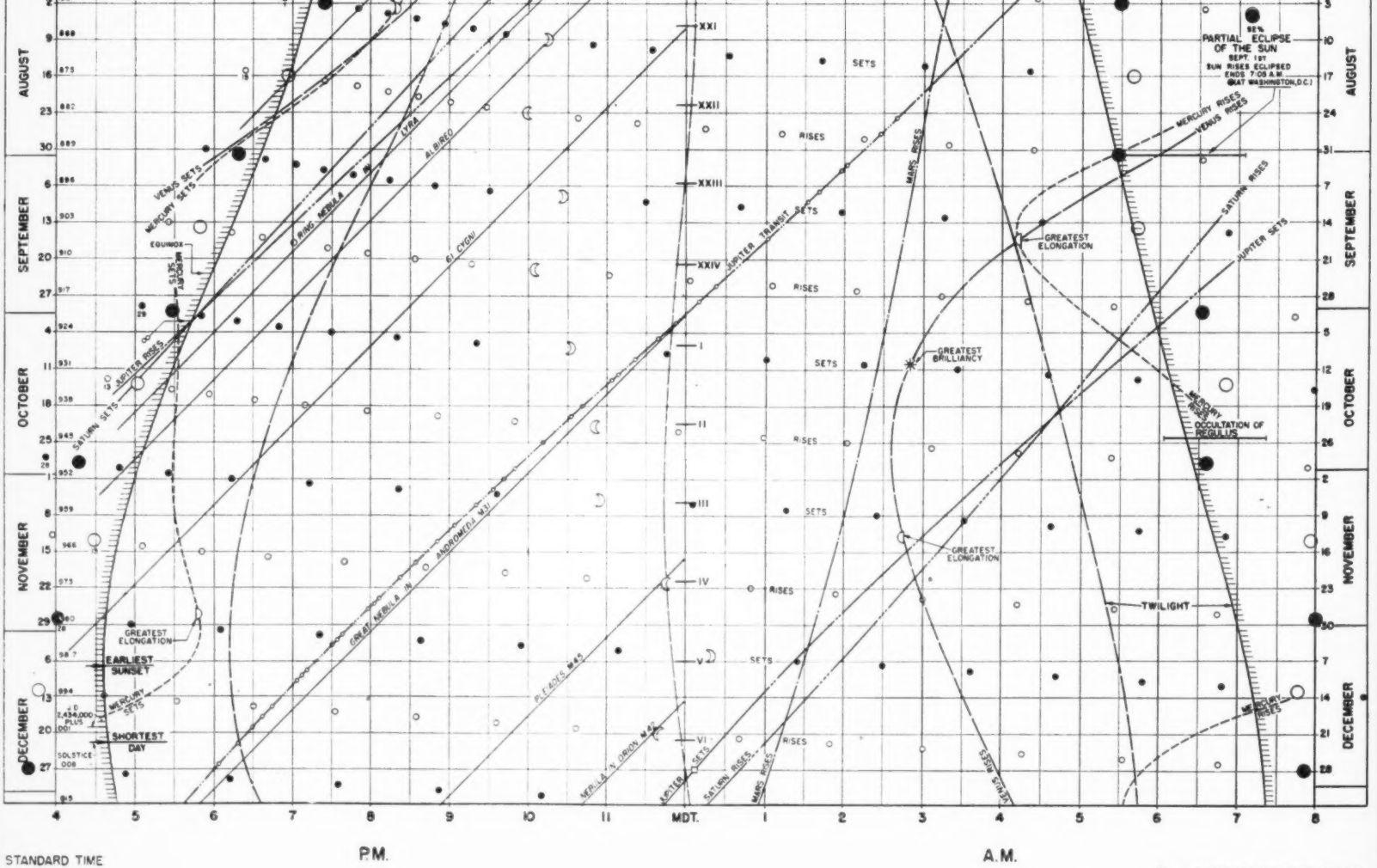
YEAR 1951





APRIL
MAY
JUNE
JULY
AUGUST
MERCURY SETS
VENUS SETS
GREATEST ELONGATION
GREATEST BRILLIANCY
LATEST SUNSET
LONGEST DAY
SOLSTICE
MERCURY SETS
MARS SETS
SATURN TRANSIT
OCCULTATION OF REGULUS
GAMMA VIRGINIS
EPSILON BOOTIS
HERCULES
CLUSTER M3 IN
LYRA
ALBIREO
RING NEBULA
XIII
XIV
XV
XVI
XVII
XVIII
XIX
XX
XXI
XXII
XXIII
JUPITER RISES
SATURN SETS
RISES
SETS
MARS RISES
EARLIEST SUNRISE
JUPITER TRANSIT
MERCURY RISES
SATURN RISES
VENUS RISES
PARTIAL ECLIPSE OF THE SUN
SEPT. 1ST
SUN RISES ECLIPSED
ENDS 7:08 A.M.
(AT WASHINGTON, D.C.)


APRIL
MAY
JUNE
JULY
AUGUST
SUN SETS ECLIPSED
(AT WASHINGTON D.C.)
SATURN RISES
GREATEST ELONGATION
REGULUS
MERCURY SETS
GAMMA VIRGINIS
SATURN TRANSIT
MARS SETS
OCCULTATION OF REGULUS
EPSILON BOOTIS
MERCURY SETS
SOLSTICE
LONGEST DAY
LATEST SUNSET
GREATEST ELONGATION
CLUSTER M13 IN HERCULES
GREATEST BRILLIANCY
GREATEST ELONGATION
XII
XIII
XIV
XV
XVI
XVII
XVIII
XIX
XX
XXI
RISES
SETS
MERCURY EQUINOX
MERCURY RISES
MARS RISES
GREATEST ELONGATION
EARLIEST SUNRISE
SATURN SETS
JUPITER RISES
MERCURY RISES
JUPITER TRANSIT
98%
PARTIAL ECLIPSE OF THE SUN
SUN RISES ECLIPSED
ENDS 7:05 A.M.
(AT WASHINGTON, D.C.)



STANDARD TIME

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II. An annular eclipse of the Sun, September 1, 1951, the annular path beginning at sunrise near Durham, N. C., and moving southeastward across the Atlantic and Africa and ending at sunset on the island of Madagascar. The partial phases will be visible from the eastern half of North and Central America, Europe, except Scandinavia, and all of Africa.

The circumstances of the eclipse, in Central Standard Time are as follows:

		d	h	m	Longitude ° ′	Latitude ° ′
Eclipse begins	September	1	3	54.5	+ 64 10	+33 8
Central Eclipse begins		1	4	58.7	+ 80 56	+36 19
Central eclipse at local apparent noon		1	6	42.0	+ 10 28	+18 42
Central eclipse ends		1	8	44.0	— 46 9	—18 38
Eclipse ends		1	9	48.1	— 29 35	—21 50

As seen from St. Louis, Mo., the eclipse begins before sunrise. At sunrise, which occurs at 5:30 A.M., the magnitude will be 0.52 (Sun's diameter = 1). The eclipse ends at 6:03 A.M.

At Washington, D. C., also, the Sun will rise already eclipsed, at 5:35 A.M. The middle of the eclipse will occur at 6 A.M. when 0.92 of the Sun's diameter will be covered by the Moon, and the eclipse will end at 7:07 A.M.

For the times at other locations consult the *American Ephemeris.*

Occultations

During 1951 two occultations of the bright star Regulus (α Leonis) will be visible over most of the United States. The first occurs on the evening of June 10. The Time Table gives the times of immersion and emersion as seen at Washington, D. C., but from longitude 91° west and latitude 40° north these times are: immersion at 7:20 P.M., C.S.T., and emersion at 8:13 P.M., C.S.T. The second will occur on the morning of October 25, and the times at the same location are: immersion 4:47 A.M., emersion 5:50 A.M. This last figure is after the beginning of morning twilight.

Also, from longitude 91° west and latitude 40° north, an occultation of Venus will occur on the afternoon of February 7, immersion being at 4:49 P.M. and emersion at 5:36 P.M. (both C.S.T.). This occultation will not be visible from the eastern part of the United States.

Maryland Academy of Sciences, Baltimore, November 22, 1950.

The Planets in February, 1951

By RAYMOND H. WILSON, JR.

Note: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac.*

Sun. Continuing its motion northward since the winter solstice, the sun will be only 8 degrees south of the equator at the end of this month.

Moon. The phases of the moon will occur as follows:

New Moon	February	6	2 A.M.
First Quarter		13	3 P.M.
Full Moon		21	3 P.M.
Last Quarter		28	5 P.M.

The moon will be at perigee on February 3.

An occultation of Venus will be visible from the northern half of the United States in the late afternoon of February 7. The time of immersion will vary from shortly before 2 P.M., P.S.T., on the west coast to shortly after 6 P.M., E.S.T., on the east.

Evening and Morning Stars. Venus will be most conspicuous in the southwest twilight; near it will be Jupiter and the much fainter Mars. Saturn will be rising later in the evening.

Mercury. During the first week of the month Mercury, just past western elongation, may still be visible low in the southeast dawn.

Venus. Increasing in brilliance and receding from the sun, this planet will shine in the southwest until nearly 7 P.M.

Mars. The fading visibility of Mars in the evening twilight will be bolstered somewhat by close association with Venus, which will pass only half a degree to the south of it on February 15.

Jupiter. Jupiter, although bright, will be nearly two magnitudes fainter than Venus, which will pass half a degree to the south of it on February 11. Mars, three magnitudes fainter yet, will complete this remarkable group of planets, which will appear most concentrated on the evening of February 7, when the moon will also be among them to occult Venus.

Saturn. Saturn will be rising by 8 P.M. at the end of the month, thus returning to availability for evening observation. The rings are again narrowing, after having expanded to a width of 3 seconds of arc.

Uranus. Uranus will be moving slowly westward, midway between ϵ and η Geminorum.

Neptune. Neptune will be slowly moving north-northwestward at about a degree southeast of θ Virginis.

Department of Mathematics, Temple University, Philadelphia, Pa.
December 10, 1950.

Asteroid Notes

By HUGH S. RICE

There appear to be 5 asteroids all visible at this time in a small telescope. (a) 372 PALMA is found in Lynx and Auriga; it comes to opposition on January 4, and the magnitude is rated 9.2. (b) 40 HARMONIA is in Cancer and Gemini; its opposition date is January 19, and the magnitude 9.3. (c) 13 EGERIA is in Leo Minor, Ursa Major, and Lynx; the opposition is on February 11, and the magnitude is 9.4. (d) 20 MASSALIA is in Leo, with opposition February 12 and magnitude 8.4. (e) 28 BELLONA is also in Leo, the opposition being February 13 and the magnitude 9.2.

The last two asteroids, MASSALIA and BELLONA, have their apparent paths crossing at right ascension $9^h\,55\frac{1}{2}^m$ and declination $+11\frac{1}{2}°$. This point is west and south of α Leonis, and the planets are near the star for several weeks. They are also near each other, the distance of about $1\frac{1}{2}°$ occurring from about January 24 to February 3. The line connecting the two planets rotates around its middle, making a complete rotation in a few weeks. While the asteroids are close together in apparent position for some weeks, they are not in conjunction

at any time during the ephemeris period. This of course illustrates the fact that conjunction is not the same technically as the situation of being nearest together in apparent position.

The following ephemerides are taken from the official annual publication issued by the minor-planet headquarters at the Cincinnati Observatory. [The said annual lists the places of many others, but these other 143 asteroids are fainter, having magnitudes between the 5 offered here and magnitude 17.2, as in the case of 1519 1938 UB.]

ASTEROID EPHEMERIDES

0^h U.T. Equinox 1950

372 PALMA

1950-51	α h m	δ ° ′
Dec. 15	7 24.8	+53 23
25	7 11.4	+53 19
Jan. 4	6 56.5	+52 30
14	6 42.3	+51 2
24	6 30.7	+49 3
Feb. 3	6 23.2	+46 43

40 HARMONIA

1950-51	α h m	δ ° ′
Dec. 25	8 24.8	+21 17
Jan. 4	8 16.6	+22 10
14	8 6.2	+23 5
24	7 54.9	+23 57
Feb. 3	7 44.4	+24 39
13	7 36.0	+25 8

13 EGERIA

1951	α h m	δ ° ′
Jan. 14	10 4.0	+40 27
24	9 56.4	+41 57
Feb. 3	9 45.9	+43 7
13	9 33.9	+43 43
23	9 22.3	+43 42
Mar. 5	9 12.9	+43 5

20 MASSALIA

1951	α h m	δ ° ′
Jan. 14	10 2.6	+10 49
24	9 57.1	+11 16
Feb. 3	9 48.9	+11 58
13	9 39.4	+12 48
23	9 30.1	+13 38
Mar. 5	9 22.5	+14 20

28 BELLONA

1951	α h m	δ ° ′
Jan. 24	10 1.1	+10 21
Feb. 3	9 54.7	+11 43
13	9 47.0	+13 14
23	9 39.2	+14 44
Mar. 5	9 32.4	+16 5
15	9 27.6	+17 10

Hayden Planetarium, American Museum of Natural History, New York, 1950 December 24.

Occultation Predictions for February, 1951

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Date 1951	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION a	IMMERSION b	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION a	EMERSION b	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′										
Feb. 7	VENUS	−3.3	23 13.4	..	..	129	.. ..	..	..	...
12	μ Arie	5.7	23 47.8	−1.7	+0.5	60	1 10.6	−1.4	−0.6	252
16	354 B.Taur	6.3	2 31.4	−1.3	−3.4	135	3 32.9	−1.9	+0.6	231
18	47 Gemi	5.6	2 54.0	−1.9	−1.3	110	4 18.5	−1.4	−1.5	285
19	35 B.Canc	6.4	8 18.1	+0.2	−2.1	139	9 9.7	0.0	−1.3	268
23	τ Leon	5.2	5 38.3	−2.3	+0.1	94	6 39.7	−0.4	−2.4	348
25	49 Virg	5.3	7 33.7	−2.0	−0.3	101	8 42.1	−0.9	−1.8	336
26	BD−16°3785	6.5	9 48.2	−1.7	−1.0	108	11 2.7	−1.3	−1.7	311
28	4 Scor	5.6	8 1.6	−1.3	+0.6	103	9 14.5	−1.4	−0.2	305
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
Feb. 7	VENUS	−3.3	22 49.3	−2.0	−2.3	102	23 36.1	+0.3	+2.4	183
12	μ Arie	5.7	23 12.2	−1.6	+1.8	48	0 39.5	−2.1	+0.2	252
18	47 Gemi	5.6	2 20.9	−2.1	−1.7	131	3 41.9	−2.5	+0.7	255
18	134 B.Gemi	6.5	6 0.0	−1.8	−0.8	82	7 5.3	−0.2	−2.6	321
19	35 B.Canc	6.4	8 33.8	+1.3	−3.9	181	9 1.4	−1.7	0.0	232
23	τ Leon	5.2	5 8.4	−1.2	−0.7	133	6 24.5	−1.5	−0.9	306
25	49 Virg	5.3	7 7.7	−0.9	−0.8	141	8 21.4	−1.6	−0.6	299
26	BD−16°3785	6.5	9 21.2	−1.2	−0.9	139	10 37.3	−1.9	−0.9	291
Occultations Visible in Longitude +98° 0′, Latitude +31° 0′										
Feb. 12	μ Arie	5.7	22 43.5	−2.0	+1.7	60	0 15.7	−2.1	+1.7	231
18	BD+27°1337	6.4	2 52.5	−2.8	+2.0	66	4 9.8	−1.9	−3.1	322
18	134 B.Gemi	6.5	6 0.2	−1.5	−1.9	119	7 19.8	−1.0	−1.5	286
23	τ Leon	5.2	5 17.5	−0.2	−3.1	177	6 11.0	−2.9	+1.1	264
25	49 Virg	5.3	7 20.3	+0.6	−3.2	186	8 4.6	−3.4	+1.4	257
26	BD−16°3785	6.5	9 30.0	−0.1	−2.4	174	10 24.5	−3.2	+0.3	260
28	π Scor	3.0	9 1.6	−2.1	+1.7	71	9 52.6	−0.1	−1.6	342
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
Feb. 7	VENUS	−3.3	21 52.7	−1.8	+1.2	50	23 19.6	−1.2	+1.0	222
14	18 Taur	5.6	7 32.8	−1.7	+2.4	21	8 0.6	+1.2	−4.2	328
15	BD+26°731	6.5	8 0.5	−0.1	−2.0	115	8 58.9	−0.3	−0.6	247
16	354 B.Taur	6.3	0 49.6	..	..	134	1 33.3	..	..	197
18	47 Gemi	5.6	1 26.8	−1.6	−0.4	127	2 31.8	−1.2	+2.8	237
18	BD+27°1337	6.4	2 33.3	..	..	24	3 0.4	..	..	346
18	134 B.Gemi	6.5	5 9.4	−2.1	−2.1	131	6 34.6	−2.5	−0.2	263
23	τ Leon	5.2	4 58.0	..	..	185	5 29.2	..	..	241

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By MARGARET W. MAYALL, Recorder

Epsilon Coronae Australis. Dr. R. H. Stoy, His Majesty's Astronomer at the Royal Observatory, Cape of Good Hope, recently sent some notes from the Royal Observatory, extracted from Volume IX of the *Monthly Notes of the Astronomical Society of South Africa.* One of the notes, by A. W. J. Cousins and A. N. Cox, concerned a new naked-eye eclipsing variable in the southern sky, ϵ Coronae Australis. This fifth-magnitude star was included in a list of bright stars to be

observed photographically by the Fabry method. On two nights, five days apart, it faded appreciably in less than 2 hours, indicating a short-period variation. Dr. J. B. Irwin, of Kirkwood Observatory, Indiana University, who was visiting the Royal Observatory, observed the star photoelectrically one evening, and fortunately was able to follow it through a minimum. The light curve suggests it is a close eclipsing system of the W Ursae Majoris type, with a period of 0.8406 of a day, and a range of brightness of 0.26 magnitude. The spectrum is F5 in the Henry Draper Catalogue, and the Yale Catalogue gives a parallax of 0.026 seconds of arc. Mr. Cox, one of the authors of the paper, is a graduate student from Kirkwood Observatory, who is spending four months at the Royal Observatory carrying on photoelectric observations of the southern stars.

S Indi, 204954. Another of the notes sent by Dr. Stoy was a paper by A. D. Thackeray on the amplitude of the long-period variable, S Indi. The star was photographed with the Radcliffe 74-inch reflector on October 30, 1950, within a few days of the predicted minimum. The magnitude was determined from an extrapolation of the magnitudes in Selected Area 186. The result was an estimated minimum photographic magnitude of 17.0. Dr. Thackeray lists the published photographic magnitude as 7.9 at maximum, which gives an amplitude of 8 or even 9 magnitudes. Very few long-period variables have ranges of more than 7 magnitudes. Another Radcliffe photograph of August 28, 1948, showed the star fainter than 16.3 magnitude, so the present minimum is probably not unusually faint.

Visual observations of S Indi made by the A.A.V.S.O. show that the most recent maximum, which occurred the first of April, was a faint one, about 10.4 magnitude. The two preceding maxima in 1947 and 1948 were both brighter than 8th magnitude.

A private Observatory in Mexico. The recent issue of *El Universo* (October-December, 1950), the publication of the Astronomical Society of Mexico, contains a description of the fine observatory of Sr. Domingo Taboada. Sr. Taboada is one of the A.A.V.S.O. observers who made nearly 1000 observations of variable stars last year. The cover of *El Universo* has a photograph of his beautiful "castle" with his observatory on the top of one of its towers.

R Coronae Borealis-type Variables. All the variables of this type on the A.A.V.S.O. observing list are still at maximum. Several observers have suspected a coming minimum, but nothing has developed as yet.

Predicted Dates of Maximum of Long-Period Variables, 1951. Listed herewith are predicted dates of maximum for long-period variables which, on the average, attain a maximum magnitude brighter than 8.0. These values are taken from an AAVSO Bulletin published yearly, which contains dates of maximum and minimum for 398 variables. Copies may be obtained from AAVSO headquarters at the Harvard Observatory. In the successive columns are given the designation and name of the variable, the month and day in 1951 of the predicted maximum, and in the last column the *mean* maximum magnitude. Actual bright-brightness at maximum may differ by, a magnitude or more in some instances.

Desig.	Name	Date Max. m	d	Mean Max. Mag.	Desig.	Name	Date Max. m	d	Mean Max. Mag.
001032	S Scl	1	1	6.8	021403	o Cet	6	29	3.7
001755	T Cas	8	6	7.8	022813	U Cet	1	16	7.5
001838	R And	5	4	7.0	022813	U Cet	9	8	
021143a	W And	1	3	7.5	023133	R Tri	3	29	6.3

Desig.	Name	Date Max. m	d	Mean Max. Mag.
023133	R Tri	12	20	
025050	R Hor	3	26	6.0
043263	R Ret	9	22	7.7
045514	R Lep	9	8	6.7
051533	T Col	6	2	7.6
054920a	U Ori	3	2	6.6
055686	R Oct	8	3	7.9
061702	V Mon	10	14	7.1
065208	X Mon	4	3	7.6
065208	X Mon	9	5	
065355	R Lyn	5	23	7.9
070122a	R Gem	3	2	7.1
072708	S CMi	7	29	7.5
081112	R Cnc	4	4	6.8
082405	RT Hya	8	27	7.6
084803	S Hya	5	13	7.9
085008	T Hya	5	13	7.7
092962	R Car	1	9	4.6
092962	R Car	11	13	
093934	R LMi	10	21	7.2
094211	R Leo	9	11	5.9
100661	S Car	4	8	5.7
100661	S Car	9	4	
103769	R UMa	7	2	7.6
114441	X Cen	6	6	7.8
121418	R Crv	8	20	7.6
122001	SS Vir	9	18	6.9
123160	T UMa	8	3	7.9
123307	R Vir	4	12	6.9
123307	R Vir	9	4	
123961	S UMa	6	10	7.9
132422	R Hya	8	4	4.6
132706	S Vir	5	25	7.1
133633	T Cen	1	6	6.1
133633	T Cen	4	7	
133633	T Cen	7	7	
133633	T Cen	10	6	
134440a	R CVn	4	3	7.7
140950	R Cen	9	3	5.9
142539a	V Boo	4	16	7.9
143227	R Boo	5	20	7.3
143227	R Boo	12	30	
151731	S CrB	7	9	7.5
151822	RS Lib	6	30	7.7
152849	R Nor	2	2	7.2
152849	R Nor	7	12	
153654	T Nor	3	15	7.4
153654	T Nor	11	12	
154615	R Ser	6	14	6.8
154639	V CrB	5	6	7.4
162112	V Oph	5	11	7.5
163266	R Dra	3	12	7.6
163266	R Dra	11	12	
164715	S Her	2	12	7.6
164715	S Her	12	16	
164844	RS Sco	6	17	6.8
165030a	RR Sco	2	10	6.0
165030a	RR Sco	11	17	
170215	R Oph	2	22	7.6
170215	R Oph	12	21	
182133	RV Sgr	5	18	7.8
183308	X Oph	6	7	6.9
190108	R Aql	8	22	6.3
191019	R Sgr	1	22	7.2
191019	R Sgr	10	23	
193449	R Cyg	8	28	7.3
194048	RT Cyg	4	23	7.4
194048	RT Cyg	10	30	
194632	χ Cyg	11	21	5.3
194659	S Pav	8	11	7.3
194929	RR Sgr	4	16	6.6
195142	RU Sgr	3	17	7.2
195142	RU Sgr	11	13	
200938	RS Cyg	11	29	7.4
201139	RT Sgr	6	12	7.9
201647	U Cyg	7	23	7.6
204405	T Aqr	1	20	7.9
204405	T Aqr	8	10	
210868	T Cep	7	5	5.8
221948	S Gru	5	15	7.8
230110	R Peg	3	18	7.9
230759	V Cas	4	13	7.9
230759	V Cas	11	27	
233815	R Aqr	9	15	7.3
235150	R Phe	6	27	7.8

Observations received during November, 1950. A total of 4,550 was received during the month from 63 observers, as follows:

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Adams	60	142	Cragg	143	148
Ancarani	21	37	Darling	29	45
Bogard	47	102	De Kort	11	44
Boone	8	8	Diedrich, DeL.	4	7
Buckstaff	20	46	Diedrich, G.	4	6
Cain	2	2	Escalante	161	250
Charles	27	28	Estremadoyro, V.	1	2
Cisler	1	4	Fernald	314	623
Cobb	3	5	Ford	17	17
Cooke	32	38	Galbraith	37	189
Costello	7	8	Greenley	79	116

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Hamilton	5	8	Parker	22	22
Hartmann	174	183	Parks	17	17
Jackson	1	1	Pearcy	77	81
Jerabek	9	18	Peltier	55	237
Kato	45	149	Penhallow	4	4
Kearons	21	21	Peter	19	89
Kelly	10	10	Reeves	1	2
Knowles	28	46	Renner	190	194
de Kock	123	430	Rick	2	2
Lankford	6	7	Rosebrugh	24	112
Leutenegger	41	79	Schulte	15	18
LeVaux	33	36	Taboada	117	120
Meek	38	201	Thomson	3	8
Melville	10	26	Tifft	4	4
Meyer	3	4	Upjohn	34	35
Michiels, E.	4	35	Upton	18	22
Michiels, L.	1	2	Venter	31	44
Miller	28	100	Webb	18	20
Milone	15	15	Yamada	17	51
Morrisby	9	48	—		—
Motley	7	15	63	totals	4,550
Oravec	47	167			

Nova Search. Reports on the Nova Search Program were received during November from 6 observers, as follows:

Observer	Area	No. Nights	Mag.	Observer	Area	No. Nights	Mag.
Adams	16, 17, 39, 40	8	8	Rick, L.	Dome	13	1
	31, 32	7	8		18	15	4
Diedrich, DeL.	40	1	6		63	14	4
	40	3	5		65	7	4
	40	4	4		65	1	3
Diedrich, G.	Dome	2	1	Rosebrugh	Dome	2	3
	78	3	5		1, 34	1	4
	78	2	4	Smith, F. W.	3, 4	6	6

December 15, 1950.

Comet Notes

By G. VAN BIESBROECK

NEW COMET? A cablegram from the Central Bureau of Information at Copenhagen, dated December 1, reported the discovery of an eighth-magnitude diffuse object at the Hyderabad Observatory, Deccan, India. Dr. Akbar Ali, Director of the Nizamiah Observatory, was given as the discoverer and the following position obtained there by Mohamed Ghouse was transmitted:

1950 November 27.60 U.T.
Right Ascension $0^h\ 20^m.6$ Declination $+2^\circ\ 26'$
Daily motion $1^m\ 21^s$ west; $0^\circ\ 14'$ north.

The sky being clear here on December 4 a search for the object was made but no moving object corresponding to the above description could be found. Since no other observations of such a relatively bright object have been announced the object is still unconfirmed.

The Japanese computer, S. Kanda, has published an ephemeris for the present

return of periodic comet TEMPEL-SWIFT, which is supposed to have come to opposition at the end of November. Plates taken here with the 24-inch reflector showing stars down to 18th magnitude have not revealed the presence of the comet which must certainly be extremely faint.

The previously-mentioned faint comets that remain in reach of larger instruments follow their predicted course. Dr. L. E. Cunningham of Berkeley, California, has called my attention to my omission of mentioning comet 1949 *a* (JOHNSON) which, although faint, is still in good observing condition since it remains circumpolar for several months.

COMET 1950 *b* (MINKOWSKI) should be looked for at daybreak in the southeastern sky. The following ephemeris is computed from an orbit by Bobone, which gives 1951 January 15.2579 U.T. as the date of perihelion passage.

	α	δ	
	h m	° ′	Mag.
1950 Dec. 25	15 3.5	—19 56	10.0
1951 Jan. 4	15 1.5	—21 41	9.9
Jan. 14	14 57.1	—23 32	9.7
Jan. 24	49.5	—25 31	9.5
Feb. 3	37.4	—27 37	9.4
Feb. 13	14 19.1	—29 46	9.2
1951 Feb. 23	13 52.5	—31 40	9.1

Visibility will be best in the southern hemisphere. Northern observers can see the object only at low altitude.

Williams Bay, Wisconsin, December 12, 1950.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Lines on Sir William Herschel's Telescope

The above caption prefaces an article in an old magazine dated January, 1857, relating to some lines composed by Sir John Herschel in 1839, commemorating the great telescope with the aid of which his father had contributed so much to the advancement of astronomy. This was the large reflector of 48 inches aperture and 40 feet focal length with which Sir William Herschel made so many of his most important observations. This telescope was apparently not used to any extent after his father's death, as Sir John Herschel seems to have done most of his work with a smaller reflector of twenty feet focal length. The old telescope Sir John preserved as a monument to the memory of his father.

These lines are of interest in view of their quaint wording and the warmth of feeling they evince.

A picture of the old telescope as it appeared in 1863 is to be found in Sir Robert Ball's interesting volume "Great Astronomers" published about a half century ago. The type of mounting shown in the picture is as described in the accompanying article. To quote:

"The forty-foot telescope of Sir William Herschel is no longer in use. It

has been placed in a horizontal position, in the direction of the meridian, near the middle of the circle on which moved the mechanism which formerly controlled it. It rests on pillars of solid masonry, Sir John Herschel having so placed it, and made of it an appropriate monument to this father, who died in 1822, in the 84th year of his age."

Before the tube was closed up he sang with his six children the following requiem:

THE OLD TELESCOPE

"To be sung on New Year's eve, 1839-40, by Papa, Mamma, Madame Gerlach, and all the little bodies, in the tube assembled.

"In the old telescope's tube we sit,
And the shades of the past around us flit,
His requiem sing we, with shout and din,
While the old year goes out and the new comes in.

Chorus.

"Merrily, merrily, let us all sing,
And make the old telescope rattle and ring.

"Full fifty years did he laugh at the storm,
And the blast could not shake his majestic form.
Now prone he lies, where he once stood high,
And searched the heaven with his broad, bright eye.
Merrily, merrily, &c.

"There are wonders no living sight has seen,
Which within this hollow have pictured been;
Which mortal record can never recall,
And are known to Him only who made them all.
Merrily, merrily, &c.

"Here watched our father the wintry night,
And his gaze has been fed with pre-Adamite light;
His labours were lightened by sisterly love,
And united they strained their visions above.
Merrily, merrily, &c.

"He has stretched him quietly down at length,
To bask in the starlight his giant strength;
And Time shall here a tough morsel find,
For his steel-devouring teeth to grind.
Merrily, merrily, &c.

"He will grind it at last, as grind it he must,
And its brass and its iron shall be clay and rust,
But scathless ages shall roll away,
And nurture its fame in its form's decay.
Merrily, merrily, &c.

"A new year dawns, and the old year's past:
God send it a happy one like the last,
(A little more sun and a little less rain,)
To save us from cough and rheumatic pain.
Merrily, merrily, &c.

"God grant that its end this group may find
In love and in harmony fondly join'd,
And that some of us, fifty years hence, once more
May make the old telescope's echoes roar.

Chorus.

"Merrily, merrily, let us all sing,
And make the old telescope rattle and ring.

D. V. GUTHRIE.

Louisiana State University, Baton Rouge.

A Transitional Hypothesis Concerning Life on Interstellar Bodies

A belief that the Sun is slowly losing its ability to radiate heat and the effect this would have upon the surface temperature of the "habitable" planets, suggest a new theory, which we can call a "transition hypothesis," concerning life as we know it on these same planets.

The surface temperatures of the planets would undoubtedly, with the aid of time, become cooler and cooler at a rate proportionate to the "cooling" of the Sun. Thus, for example, a planet having a mean surface temperature of ten degrees Centigrade might, in a billion years, have that temperature reduced to minus ten degrees Centigrade, changing drastically the probability of habitation. Meanwhile, a planet closer to the Sun, whose surface temperature has heretofore been above that of human endurance, might have that temperature lowered to a state where life could exist.

Temperature, however, although an important consideration, is not the only factor determining the "habitability" of a planet. An atmosphere containing a sufficient amount of oxygen and carbon dioxide, water in a fluid state, light and vegetation for carrying out a process of photosynthesis or something similar to it, and once again a surface temperature varying between the freezing point and always below the boiling point of water, are absolutely necessary for the propagation of life. We can employ these factors to help us determine whether there was, is, or can be life elsewhere in our own solar system.

The only planets, according to our limited knowledge, that probably include all of the necessary factors for sustaining life are Mars, the Earth, and Venus. The other planets lack at least two of these factors and so can be eliminated from consideration.

There is no doubt that there is at present life on the Earth.

As to Mars, there is much evidence to substantiate the belief that there was an advanced form of life on that planet. It has light (sunlight), the possible remains of vegetation, water, and a temperature that ranges from below zero to fifty degrees Fahrenheit. Its atmosphere, however, is said to contain only one thousandth as much oxygen as that of the Earth, but if we study the surface of the planet, we see that it has the characteristic yellow-red hue of oxidized igneous rock. This strengthens the supposition that there once was an abundant supply of oxygen, but that most of it has been removed by slow oxidation of the free iron in the igneous rock. At present, only the oxygen and some water vapor have been identified in the atmosphere of Mars. Furthermore, many scientists believe that there was or still is life on Mars. One of the most famous of these astronomers, Schiaparelli, interpreted the grooves or "canals" seen on the surface of Mars as the work of intelligent inhabitants. As to what form these inhabitants assume, we have no way of discovering. Thus, we see that Mars measures up closely to the theoretical picture we would have of a planet in a late stage.

Conversely, Venus gives the appearance of a planet that might have resembled the Earth in a very early stage. A heavy atmosphere of clouds and mist completely hides the surface of Venus from us, leaving us unable to determine the

existence of many of the factors upon which life depends. It is believed, though, that the atmosphere does contain carbon dioxide, oxygen, and water vapor, and that the maximum temperature on the planet is probably close to that of boiling. This suggests that while at present there is no life on Venus, the probability that life will exist in the future as the temperature is lowered is very strong.

These facts and beliefs tend to form a systematic pattern of transitional character. One notices that as the Sun, and consequently the planets, "cool," there is a distinct "movement" of life, so as to maintain the conditions under which it has previously existed on other bodies. It would be of an evolutional character that would closely adhere to the historical pattern set on the Earth, and would suggest and strengthen our theory that life could exist on different bodies at different times. (We also notice that if two planets were sufficiently close together there would be an overlapping of existence on each planet, since both would qualify as to suitable conditions. While this may not be the case in our own system, it may very well exist in other systems.)

Consequently, a general hypothesis may be concluded from this: the existence of life as we know it in planetary systems is a transitional phenomenon that tends to flourish most easily under conditions of least stress on "habitable" bodies.

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General Notes

Mr. John W. Streeter, formerly a member of the staff at Vassar College, has assumed the position of Assistant Director of the Fels Planetarium, Philadelphia, Pa.

Dr. L. J. Comrie, well known as one of the pioneers in the use of business machines in astronomical computations, as formerly the superintendent of His Majesty's Nautical Almanac office, and as founder of the Scientific Computing Service, Ltd., died in his sleep during the night of December 10-11.

Miss Jessie V. Payne, who resided in Elgin, Illinois, for a number of years, died there on Saturday, December 30, 1950. A memorial service and the interment were held in Northfield, Minnesota, on Saturday, January 6.

Although Miss Payne was not an astronomer in the usual connotation of that term, it is highly fitting that this mention of her death should be made in this magazine. She was the daughter of Professor W. W. Payne, whose name still appears on the front cover as the founder of POPULAR ASTRONOMY. Miss Payne was associated with her father in this project as well as with the magazines which preceded it. The Sidereal Messenger, ten volumes, Astronomy and Astrophysics, three volumes, and the first seventeen volumes of POPULAR ASTRONOMY were produced while she was actively participating in the mechanical and business phases. Her work with the magazine ended when her father retired from active connection with Carleton College, at which time the College purchased POPULAR ASTRONOMY from Professor Payne. Miss Payne, therefore, is entitled to credit with her father in the pioneering work done by them fifty and more years ago.

Instrument News.—The first number of Volume 2 of this quarterly publication, issued by the Perkin-Elmer Corporation of Glenbrook, Connecticut, has recently been received. A number of interesting production situations are described in it. Of most interest to astronomers is a large-scale photograph of the Curtis Telescope of the University of Michigan. This is a 24-inch by 36-inch Schmidt camera recently dedicated at the University's Portage Lake Observatory. The mounting was made by the Warner and Swasey Company, and the optical work was done by Perkin-Elmer.

Provisional Sunspot Numbers for November, 1950*

1	78	11	46	21	22
2	62	12	48	22	18
3	57	13	42	23	16
4	67	14	61	24	20
5	79	15	81	25	26
6	94	16	42	26	32
7	80	17	66	27	64
8	55	18	58	28	74
9	61	19	50	29	69
10	60	20	36	30	73

Mean 54.6

*From the Zürich Observatory, furnished by Mr. Neal J. Heines.

The Cleveland Astronomical Society

The Cleveland Astronomical Society held its annual Christmas party at the Warner and Swasey Observatory December 15, 1950. Dr. John Irwin of Indiana University was the speaker of the evening.

Dr. Irwin flew to South Africa last summer on an astronomical mission returning via western Europe and the British Isles, also by plane. He spent about four months in South Africa doing photoelectric photometry at three of the observatories, the Radcliffe Observatory at Pretoria, the Lamont-Hussey Observatory at Bloemfontein, and the Royal Observatory at Cape Town. He also visited the Union and Yale Observatories in Johannesburg and several in Europe and England.

Dr. Irwin gave the Society an interesting account of his trip which was well illustrated with a splendid set of colored slides. He seems to be somewhat of a mountain climber as well as an astronomer. During his spare time he was always looking for the highest peak in the area and proceeded to climb it. Perhaps he was looking for a site to place a new telescope.

The lecture and pictures were enjoyed by all, especially by the writer as many of the scenes were familiar ones. The second part of the party consisted of refreshments and an opportunity to meet old friends and get acquainted with new ones.

HENRY F. DONNER, *Recording Secretary.*

Western Reserve University, Cleveland 6, Ohio.

Astronomical Fellowships

It is expected that two Astronomical Fellowships will be open at the University of Arizona next year, one in the Department of Astronomy and the other in the Steward Observatory. In each case, the stipend will amount to $750, with exemption from tuition and laboratory fees. A moderate amount of assistance

will be expected from each Fellow: the teaching of two elementary laboratory sections in connection with the Department Fellowship, and some assistance in observing in connection with the Observatory Fellowship. The twelve-inch and 36-inch reflectors may be used for research programs involving photographic or photoelectric photometry.

Fellows may earn the master's degree in astronomy at the University of Arizona, but preference in appointment will be given to applicants who wish to take their doctor's degree elsewhere and to use the Steward Observatory equipment for the observational phases of their doctoral theses.

Applications should be addressed to the Director of the Steward Observatory, University of Arizona, Tucson, Arizona.

1950 December 1.

Committee on Teaching of Science

The American Association for the Advancement of Science has organized a committee for the improvement of science teaching, especially in elementary and secondary schools. A meeting of that committee was held in Washington, D. C., last November. Two of the four sessions were held jointly with a committee of the United States Office of Education.

Evidence that there is need of improvement in science teaching is indicated by the prevalence of periodicals on astrology and in the popularity of "Worlds in Collision." It was agreed that better teaching requires better teacher training, more laboratory space and equipment. Teachers need more opportunities to study the subject taught. Superintendents and school boards should recognize that need and give credit for promotion to teachers taking summer courses in their own subject rather than more in the field of education, even though such courses may not lead to a higher degree. It is desirable that elementary astronomy be offered in every teachers college and that courses in descriptive astronomy of one or two semesters be offered in other colleges and in universities.

The committee can in general only plan programs. Carrying them out must depend on individual citizens in each community.

The undersigned was the representative of the American Astronomical Society at the November meeting of the committee. LEAH B. ALLEN.

Hood College, Frederick, Maryland.

The Card Catalogue of Eclipsing Variables

One of the many serious problems caused by the untimely death of Professor Newton L. Pierce was the disposal of the Card Catalogue of Eclipsing Binaries. The value of this catalogue, originated by the late Professor Raymond S. Dugan and continued by Professor Pierce since 1940, is too well known to astronomers generally to need elaboration.

While it is obviously impossible to replace Dr. Pierce's sound judgment and broad knowledge of the field of eclipsing binaries, it is vitally important to continue to keep the catalogue up-to-date and useful. Therefore, with the gracious consent of Mrs. Pierce and Mrs. Dugan, and the generous permission of the Princeton University Observatory, the catalogue and the associated Finding List material have been moved to the University of Pennsylvania. It is our intention to keep the catalogue, to add to it as new material becomes available, and to publish, as often as seems practicable, lists of addenda and new editions of the Finding List.

One of the great values of the Card Catalogue lay in the fact that the material in it was made available to all interested astronomers. This practice will be continued, and we will be happy to supply data from the catalogue to any astronomer requesting it. Another feature of great value lay in the fact that so many working astronomers enhanced the usefulness of the catalogue by sending to Dr. Pierce or to Dr. Dugan their unpublished results and the names of the stars on their observing programs. This feature can be retained only by the continued cooperation of the astronomers generally, and a sincere plea for this cooperation is hereby made.

Because of the whole-hearted cooperation of the Princeton Observatory, we believe that no recent publication will be inadvertently overlooked in the rearrangements necessitated by the transfer. We will be grateful, nonetheless, if astronomers who have published in recent months articles dealing with eclipsing binaries, will be kind enough to send us reprints of these articles; this will remove any possibility of such publications being missed. We are, of course, rechecking our library files to make certain that we are receiving all current periodicals. It is difficult, however, in the case of Observatory publications which appear intermittently, to be certain that we are on the mailing list of all Observatories. We wish, therefore, to request any Observatory not at present mailing us its publications to have the kindness to put us on its mailing list.

FRANK BRADSHAW WOOD.

Flower and Cook Observatories, University of Pennsylvania, Philadelphia 4, Pa., October 17, 1950.

The Fiftieth Anniversary of the Königstuhl Observatory

The following paragraphs, a part of an address given by Dr. A. Kopff at the fiftieth anniversary of the Königstuhl Observatory, were translated from the German by Alma M. Hammer, instructor in German in Carleton College.

Allow me to begin with a confession. If one lives on the Königstuhl, has, during the day, the broad view over the plains and hills, at night the starlit sky in wonderful clearness, has in addition the task to explore this sky, then one becomes dubious about it. Our people are in the greatest distress. Does it not appear to be a flight from this world when the astronomer up on the mountain pursues his own thoughts and turns to questions which are far removed from the cares of the day?

Astronomy as a part of our work is expected to investigate—in fair competition with the other peoples of the earth; it should teach this newly discovered material. That is its foremost duty. But it must not remain aloof to the needs of our time; its position should be in the middle of the world. To be sure, astronomy can not eliminate material needs. Neither is it able to determine destiny from the stars, as many might believe, who listen to false prophets.

But there is a much greater need than the material. An inner need torments our people, and we must not relent in this attempt for inner freedom. In this situation astronomy also has a task to perform. It is qualified as few sciences are, and is in a position to operate, to have a broadening effect. It should not flee the world, rather it should gather strength for the world.

It should spread the prominent ideas throughout the cosmos, so that the cares of the world may be reduced to their due proportions. This should be one of its tasks.

In the midst of these times, in the middle of a world of scepticism and cares,

comes a commemorative occasion: the fiftieth anniversary of the Königstuhl Observatory. Here, in June, 1898, the inaugural celebration took place in the presence of the Grand Duke Frederick I, but in the sumer of 1897 observations had already begun on this mountain peak. Fifty years have since elapsed. It has been a half-century of tempestuous development also in our science, an epoch instilled with new knowledge in an unexpected manner.

Such epochs have been witnessed repeatedly in the history of our science: *viz.*, in antiquity the golden era of Greek astronomy from about the 6th to the 3rd century B.C., created by the association of the Babylonian skill at observation with Greek thought; then, after an astonishingly long intellectual interlude of many centuries, Nicholas Copernicus, who pondered anew the structure of the universe, and whose work actually signified the conclusion of Greek astronomy.

The really modern discoveries—dependent, to be sure, on the achievements of Copernicus—first appear with Kepler, who derived his laws from the observations of Tycho Brahe. Kepler named one of his works "The New Astronomy or Physics of the Heavens as shown by an Investigation of the Movement of Mars." A new idea had appeared. For the geometric description of the ancient astronomers and Copernicus, Kepler substituted the physical conception of the process of motion through the laws of mechanics. The observations of Tycho Brahe formed the basis, the exactness of which could be increased by new types of instruments. Theories and instruments led astronomy to a new level of knowledge. The subsequent centuries brought about the completion of this mechanical conception of the universe, the foundation of which attained its final form through the laws of Newton.

From the middle of the 19th century on, new ideas gradually appeared in the foreground. The physical science of the heavens of Kepler consisted in mechanics. Now the optics (in the broadest sense) appeared at its side. The mechanics of the heavens had concerned itself only with the position and motion of the stars; it attempted only to establish the direction of the ray which reaches us from one individual star. In this case the combination of the telescope with the measuring instrument has again essentially increased the precision of observation beyond Tycho Brahe's achievements. Now analysis is added to the mere determination of the direction of the ray. The brightness and spectrum of the stars are determined. Once again it is the combination of theory and instruments which furnishes the inspiration for the research. There is to be seen at the "Riesen" in the main street this memorial tablet: "In this house in 1859 Kirchhoff applied his spectral analysis, which he and Bunsen had established, to the sun and stars, thereby opening up a new field: the chemistry of the universe." The theorist Kirchhoff in collaboration with the practical-minded Bunsen completed the new step. Today, to be sure, we should prefer to replace the term chemistry of the universe by physics of the universe. For we believe the physical condition of the constellations to be more important than the investigation of their chemical composition. In this, above all, spectral analysis has given us a deep insight.

Book Reviews

Photography in Astronomy, by E. W. H. Selwyn. (Eastman Kodak Company, Rochester, New York, 1950, $2.75.)

This nicely illustrated little book of 112 pages will be of value to the practicing astronomer chiefly for its detailed and authoritative recommendations for

the processing of astronomical photographs. It is this part of the book which the author himself considers most important. Other topics that are given compact but sound treatment are "The Faintest Star Photographable," "Failure of the Reciprocity Law," and the modern "Theory of Latent-Image Formation." In an endeavor "to provide an introduction to the practice of astronomical photography," the author has also included summary discussions of a number of other subjects: "Objects Photographed in Astronomy," "Telescopes and Cameras," and "Measurement of Stellar Magnitudes," for example. These parts of the book are at once superficial and too highly condensed. The book is marred by a number of mistakes or errors of proof-reading, the most important of which occur in the formulae on page 83. ARMIN J. DEUTSCH.

Harvard College Observatory, December 2, 1950.

The Nininger Collection of Meteorites, by H. H. Nininger and Addie D. Nininger. (American Meteorite Museum, Box 1171, Winslow, Arizona. $3.00.)

On the title page of this volume one finds, in addition to the title, the descriptive phrase "A Catalog and a History." This means that in the introduction of eighteen pages, the authors have described the development of their interest in and successful prosecution of meteoritic study during more than a quarter of a century. A number of features in connection with such a project, which could not be foreseen, are referred to in detail in the history. Future meteoritic investigators will benefit from the experiences here set forth. Following the introduction there are six maps of the States of Colorado, Kansas, Nebraska, Wyoming, New Mexico, and Texas, the region in which most of the work was done by the Nininger. On these maps the locations of meteorite falls (both witnessed and unwitnessed) are marked. Two-hundred sixty-one such locations are indicated. Then follow 79 pages of detailed data relating to the falls. For convenience in using the data, the falls are arranged alphabetically. In the case of many falls the tabular data mentioned above are supplemented by field notes giving information as to the circumstances of the fall. The sixteen pages devoted to the field notes hold the attention of the interested reader as closely as a thrilling story might do. The total number of falls represented in the lists is 587 and the total number of main masses in the collection is 145. There is a brief appendix relating to tektites. A page is devoted to miscellaneous material, not strictly meteoritical, in the collection. The rest of the volume is taken up with 38 full page plates made from photographs of the many specimens in the American Meteorite Museum, with explanations of them. A study of these plates affords a good understanding of the various types of meteorites.

The American Meteorite Museum is located about 20 miles west of Winslow, Arizona, very close to Highway 66. It is within easy view of the Canyon Diablo, Coconino County, Arizona, Meteorite Crater. The writer recently had the privilege of a visit to the Crater and to the Museum in the same afternoon. The Crater is extremely impressive as a stupendous natural feature. The Museum, in its way, is equally impressive in showing what can be accomplished by two persons in a quarter of a century, through persistent, painstaking, and intelligent effort. C.H.G.

NOTE: The printing and mailing of this issue have been delayed because of the absence of the editor who attended the meeting of the American Astronomical Society at Haverford College. The February issue, which will be mailed soon after February 1, will contain a report of the Haverford meeting. EDITOR.